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TEACHER INFLUENCE AND PUPIL ACHIEVEMENT
IN ELEMENTARY SCIENCE

by
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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Teacher Influence and Pupil Achievement in Elementary Science," submitted by Peter Easter Slinn, in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

The purpose of this study was to investigate the relationship between grade six pupil achievement in the inquiry skills of science and teacher-pupil verbal interaction patterns. Included in the analyses of the data were the relationships existing among pupil intelligence and sex, teacher experience and science background, and pupil achievement in inquiry in science.

The target population included approximately fifty teacher-class units from the Edmonton Separate School District, Number 7. These sixth-grade teacher-class units represented all the Separate schools who were using a new elementary science program. (The Curriculum Guide for Elementary School Science (1968) describes the new program; a program which stresses the development of inquiry process skills.) A random sample of eight teacher-class units was selected from the target population.

Flanders Interaction Analysis was used to collect data on the verbal patterns of the eight teachers. Four months (February-May, 1969) were required to collect this data. Pupil intelligence and sex were collected from the schools' records. Each of the 259 pupils was tested in May, 1969, using the Sequential Test of Educational Progress - Science test, Form 4A (STEP).

The major results of the study were:

1. For the eight teachers under study, there is a significant difference in the verbal interaction patterns of those classified as indirect compared with those classified as direct.

2. For the eight teachers under study, teacher experience and science background are not significantly related to pupil achievement

in inquiry in science.

3. There is no significant interaction among pupil intelligence or sex, teacher-pupil verbal interaction patterns, and pupil achievement in inquiry in science.

4. There is a significant relationship between teacher-pupil verbal interaction patterns and pupil achievement in inquiry in science. The pupils whose teachers were classified as indirect achieved higher than did the pupils whose teachers were classified as direct.

5. Indirect teachers are more flexible, i.e., they tend to vary their verbal interaction patterns more according to the nature of the classroom activity.

What factors differentiate the indirect teacher from the direct teacher; the flexible teacher from the inflexible teacher? The indirect teacher: (a) talks less, (b) uses, develops, and encourages the pupils' ideas more often, (c) asks more questions, (d) lectures less often and for shorter periods of time, (e) criticizes pupils less often, (f) has pupils who respond more to questions and who exhibit more lengthy periods of sustained, pupil-initiated responses to the lesson. The flexible teacher, in comparison with the inflexible teacher: (a) is generally more indirect than direct in his classroom verbal interaction patterns and (b) exhibits a wider range of verbal interaction patterns as the classroom activities vary. For example, when the classroom activities involve the introduction of new science content, demonstration of experiments, and individual pupil experimentation, the flexible teacher tends to be more indirect. But as the pupils' learning goals become more clear, the flexible teacher tends toward a more direct approach. The inflexible teacher, on the other hand, tends toward a fairly consistent pattern of verbal interaction .

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CHAPTER I

THE PROBLEM

INTRODUCTION

A new science curriculum was introduced into Alberta elementary schools in September, 1968.

This new program has two fundamental but inseparable objectives:

1. To develop a number of basic science concepts,
2. To develop the ability to inquire through the use of process behaviors such as observing, classifying, communicating, inferring, predicting, formulating hypotheses.

The Curriculum Guide for Elementary School Science (1968) emphasizes that:

. . . the process skills should be developed and used as they are required by the student to gain and process data in order to develop concepts. The intent is that the teacher will develop a balanced program where process and content receive equal emphasis [p. 10].

But how should the teacher provide for learning experiences that foster the growth of inquiry skills? For those teachers who have treated science as dogma, the change to this new program is marked and radical. Science must now be regarded as an active process for acquiring knowledge about the world; a process designed to provide the learner with direct confrontation with these inquiring activities. The Curriculum Guide (1968, pp. 20-21) offers the following suggestions to the incumbent teacher:

1. The teacher's role should shift from that of dispensing facts and information to providing children with opportunities for discovering

this knowledge for themselves.

2. The teacher should encourage students to question and wonder about things.

3. Children should be given an opportunity to develop their own theories.

4. The teacher should assume the role of an attentive listener and to assist the children to be more self-sufficient.

5. Many of the process skills can be developed only through direct experience.

6. The discovery approach should not imply that the teacher will allow the whims of the students to guide the science program.

7. Students' investigation involving the construction of hypotheses are necessary.

8. A permissive classroom atmosphere must prevail which encourages the examination of discovered evidence and the assessment of hypotheses in terms of this evidence.

These suggestions concerning the processes and methods of inquiry in science imply special teaching techniques, such as: skilful questioning of students (Suchman, 1960); a classroom climate conducive to effective interaction between students and the teachers (Flanders, 1965); a shift from extrinsic to intrinsic motivation (Bruner, 1961); and provision for the active involvement of students with science materials (Piaget, 1964).

The results of recent research (Butts and Jones, 1966; Scott, 1966; Suchman, 1960) dealing with teaching approaches that will develop these inquiry skills are not very encouraging. In addition, there is limited evidence to clearly support the discovery approach over the

expository approach to teaching as defined by Bruner (1961).

It should be emphasized that these research studies have tended to concentrate on approaches to teaching inquiry rather than on teaching methods and the creation of an appropriate classroom climate for teaching inquiry.

At a recent Conference on Elementary Education in Banff, Gage (1967) suggested that researchers should examine some new criteria in their quest for identifying successful teacher influence (i.e., successful methods and climate for learning). Included in the criteria listed by Gage were verbal interaction analysis as developed by Flanders (1967) and the study of teacher's verbal behavior as developed by Smith (1961).

There are many recent studies described in the literature dealing with interaction analysis as developed by Flanders (1967). Almost without exception the results of the research support the hypothesis that certain indirect teacher influence and teacher flexibility are conducive to achievement. Increased achievement occurred in elementary as well as in secondary classes and in a variety of subject fields, including social studies, mathematics, science, language, and reading.

It is important to note that none of the studies, using interaction analysis, has attempted to measure achievement in inquiry skills in science at the elementary or secondary level.

How should the teacher provide for learning experiences that foster the growth of inquiry skills? A substantial body of research supports the hypothesis that indirect teacher influence and flexible teacher influence result in higher achievement in content areas. Why should not this type of teacher influence affect the development of inquiry skills among elementary school science pupils?

The wedding of the study of teacher-pupil interaction analysis with the goals involved in teaching inquiry behaviors seems not to be promiscuous.

In this study an attempt is made to ascertain the significance of teacher-pupil interaction patterns for the successful provision of student learning experiences in the development of inquiry skills in science.

DEFINITIONS OF TERMS

For the purpose of this study the following definitions will be used:

Direct Teacher Influence

Flanders (1967) defines direct teacher verbal influence as:

Direct influence consists of stating the teacher's own opinion or ideas, applying or enlarging the pupil's action, criticizing his behavior, or justifying the teacher's authority or use of that authority [p. 109].

Indirect Teacher Influence

Flanders (1967) defines indirect teacher verbal influence as:

Indirect influence consists of soliciting the opinions or ideas of the pupils, applying or enlarging on those opinions or ideas, praising or encouraging the participation of pupils, or clarifying and accepting their feelings [p. 109].

Interaction Analysis

Flanders (1965, pp. 18-48) developed a means with which to analyze teacher-pupil interaction patterns. (Appendix A)

Interaction Matrix

For the purpose of this study a ten column, ten row matrix plot

will be used to analyze teacher-pupil interaction data. From the matrices teacher direct and indirect influence patterns and teacher flexibility will be calculated. (Appendix B)

I/D Ratio

The I/D ratio for a teacher's interaction matrix will be calculated as the Columns 1, 2, 3, 4 totals divided by the Columns 5, 6, 7 totals; i.e., the teacher's indirect influence (I) divided by the teacher's direct influence (D). (Appendix B)

Classroom Activity

For the purpose of this study, all classroom activities for which verbal interaction data are to be collected will be classified into one of five mutually-exclusive categories:

- i) Routine administrative matters (pencil sharpening, settling down, cleaning-up, returning papers, administrative details).
- ii) Discussion of new material (teaching science material new to students).
- iii) Discussion of previously learned material (oral review, recapitulation).
- iv) Laboratory science activities (students performing and demonstrating experiments, teacher supervising individuals).
- v) All other activities.

Teacher Flexibility

Flanders (1965) defines teacher flexibility as:

Flexibility of teacher influence can be shown by calculating separate I/D ratios for different types of classroom activities. The wider the range of a distribution of I/D ratios, the more a teacher is modifying his influence to fit the different types of classroom activities [p. 102].

For the purpose of this study, separate I/D ratios are to be calculated for: (a) the combined interaction matrix for classroom activities i) and iii), and (b) the combined interaction matrix for classroom activities ii) and iv). A particular teacher's flexibility score will be found by subtracting (a) from (b), above. One stipulation will be made--the range will be considered positive if the I/D ratio for classroom activities ii) and iv) is larger than the I/D ratio for categories i) and iii). Conversely, the range will be considered negative if the I/D ratio for classroom activities ii) and iv) is smaller than that for classroom activities i) and iii).

Per Cent Teacher Talk

In a teacher's interaction matrix, the totals for Columns 1-7 divided by the total for Columns 1-10 represents the percentage of time that the teacher was talking. (Appendix B)

Per Cent Pupil Talk

In a teacher's interaction matrix, the totals for Columns 8-9 divided by the total for Columns 1-10 represents the percentage of time that the students were talking. (Appendix B)

Per Cent Silence

In a teacher's interaction matrix, the total for Column 10 divided by the total for Columns 1-10 represents the percentage of time for which there was silence or confusion.

Classroom Climate

Using the definitions of direct and indirect teacher influence, Flanders (1967) defines climate as:

The words classroom climate refer to generalized attitudes toward the teacher and the class that the pupils share in common in spite of individual differences. The development of these attitudes is an outgrowth of classroom social interaction. As a result of participating in classroom activities, pupils soon develop shared expectations about how the teacher will act, what kind of person he is, and how they like their class. These expectations color all aspects of classroom behavior, creating a social atmosphere or climate that appears to be fairly stable, once established. Thus the word climate is merely a shorthand reference to those qualities that consistently predominate in most teacher-pupil contacts and contacts between pupils in the presence or absence of the teacher [pp. 103-104].

Inquiry Skills

The American Association for the Advancement of Science (AAAS) developed a program entitled, Science - A Process Approach (1965).

The new Alberta elementary science program, which has adopted the AAAS science inquiry skill, lists twelve basic inquiry skills. (Appendix C).

SIGNIFICANCE OF THE STUDY

Most teachers who are confronted with a new curriculum are concerned with effective teaching of the behavioral goals inherent in that curriculum.

The goals involved in teaching inquiry behaviors are particularly intangible. Hence, any light that may be generated within this study towards establishing relationships between effective teaching behaviors and pupil development of skills in inquiry may offer some guidelines to the incumbent teacher.

On the subject of teacher effectiveness research, Biddle (1964) suggests that:

. . .few if any 'facts' seem to have been established concerning teacher effectiveness, no approved method of

measuring competence has been accepted, and no methods of promoting teacher adequacy have been widely adopted

Teachers are being called upon for higher levels of performance, administrators are expected to enlarge their schools and to raise the standards of education, teacher educators are flooded with burgeoning enrollments. An increased understanding of teacher effectiveness will help each of these groups and strengthen greatly the position of American education [p. 2].

The results of this study may have implications in the areas of: in-service education for practicing teachers; teacher education at the university level; recruitment policy in the selection of elementary science teachers; and objective evaluation of the teaching-learning environment by administrators.

THE EXPERIMENTAL SETTING

The experimental design is reported in detail in Chapter III. A brief synopsis is presented here for the purpose of orientation.

A sample of eight grade six teacher-class units are to be selected at random from 23 schools in the Edmonton Separate School District, Number 7, presently using the new science program. Flanders verbal interaction analysis data will be collected for the eight teacher-pupil units over a three-month period. The eight teachers will then be classified as indirect, average, or direct according to their respective I/D ratios. The 259 pupils in the sample will be tested in May, 1969, using the Sequential Test of Educational Progress - Science test, Form 4A (STEP). (Appendix D)

The relationships between and among pupil achievement in inquiry in science, pupil intelligence and sex, and teacher science background, experience and verbal interaction patterns are to be analyzed. Multiple linear regression analysis and Pearson Product Moment correlations are to be employed.

CHAPTER II

REVIEW OF RELATED LITERATURE

AND THEORETICAL ORIENTATION

The purpose of this thesis is to attempt to establish relationships between teacher influence and pupil achievement in inquiry in science.

In order to present a cogent theoretical framework, this chapter will treat three main areas:

1. A general framework for the study of the problem.
2. A brief analysis of what constitutes effective teaching together with selected research results.
3. A discussion of inquiry including related research as presented in the literature.

The goal of this chapter is simply to present a rationale for marrying the development of inquiry skills in science with contributing teacher behaviors (as measured by Flanders Analysis).

GENERAL FRAMEWORK

In order to set a general frame of reference to deal with the problem in this thesis, a number of bench marks will be presented. The framework may be examined under four main areas: (a) prediction sources, (b) situational factors, (c) behaviors and interaction, and (d) pupil achievement. Figure 1 represents these four areas. The basis of this model comes from Biddle (1964, p. 7). However, the framework has been changed and adapted for the purpose of the present study.

The first type of variable, prediction sources, is represented by

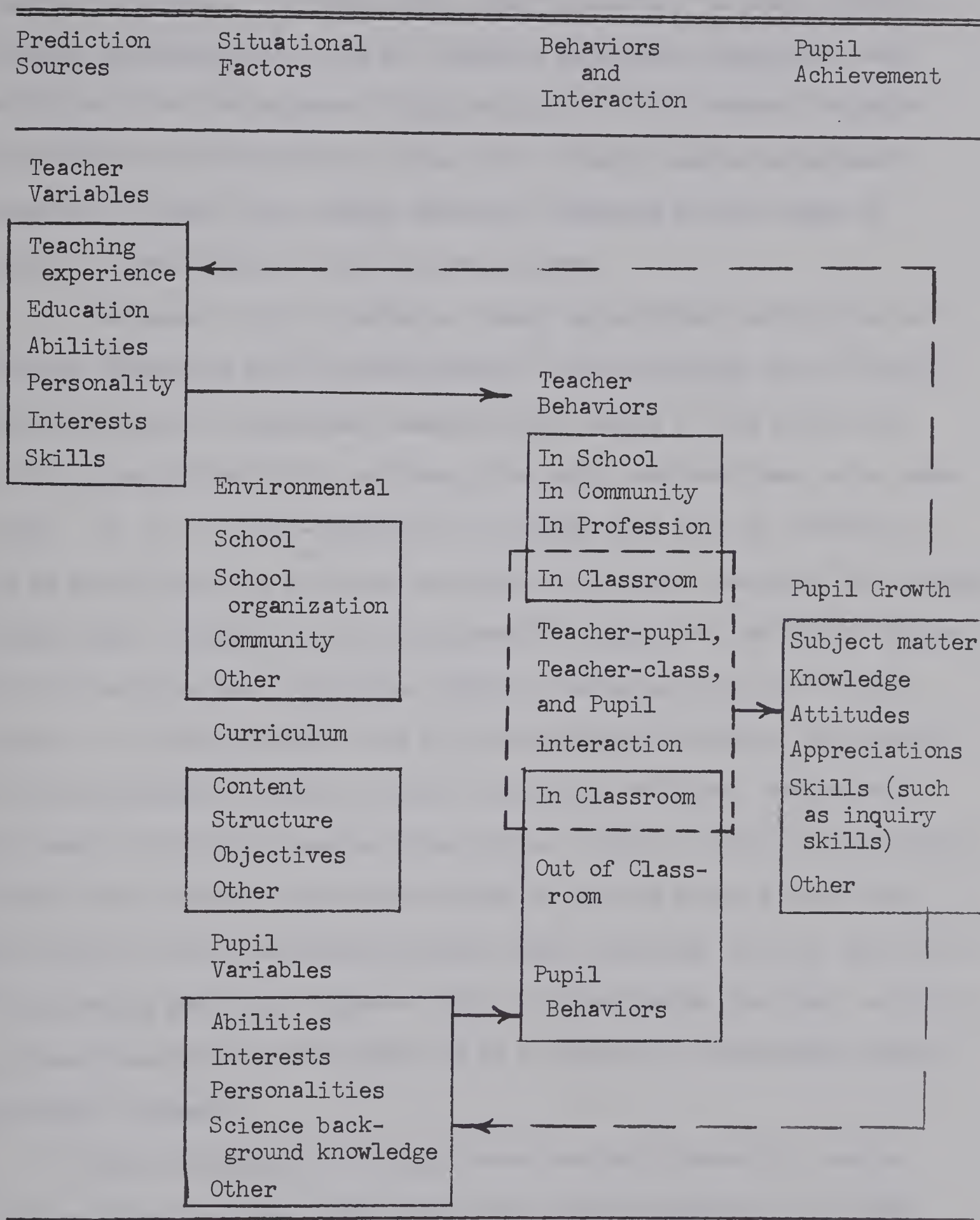


FIGURE 1

Framework for the Study of Teacher Influence
and Pupil Achievement in Inquiry in Science

teacher variables. In other words, pupil growth may be predicted from teacher characteristics such as: teaching experience, education, and abilities. For the purpose of this study two of the teacher variables as prediction sources will be taken into account; teacher experience, measured in years, and teacher education, measured by the number of science courses taken at the university level.

The second type of variable, namely situational factors, may be further classified as: (a) environmental, (b) curriculum, and (c) pupil. The environmental variables, especially the nature of the school and school organization, will vary among the eight teacher-class units under study. It is virtually impossible to control this type of variable in an ex post facto type of study other than by randomly sampling the teacher-class units. Implied in the hypotheses that appear at the end of Chapter III is the hope that the teacher behavior variables will affect pupil growth to a greater extent than will environmental factors. The second of the situational factors, namely curriculum variables, are the same for each of the eight teacher-class units. That is to say, the population under study involves only those classes on the new science curriculum. The third of the situational factors, pupil variables, will be dealt with by recording pupil intelligence (IQ). In other words, the final analysis of covariance will contain pupil IQ as a control for differences among the eight classes.

The third type of variable, behaviors and interaction, may be further classified into three areas: (a) teacher behaviors, (b) pupil behaviors, and (c) classroom interaction. Research has shown the importance of pupil-pupil interaction and the importance of nonverbal classroom activities in the academic growth of pupils. However, for this

study, it will be assumed that teacher-pupil interaction will be a representative measure of all activities, verbal and nonverbal, that occur in the course of the day-to-day learning activities. Acts of teacher influence are expressed primarily through verbal statements. It is assumed that the quality of the teacher's nonverbal acts is similar to his verbal acts.

The fourth type of variable, described as pupil achievement, will be delimited to achievement in inquiry skills. The Sequential Test of Educational Progress - Science test, Form 4A (STEP) will be used to measure the development of inquiry skills. (Appendix D)

EFFECTIVE TEACHER BEHAVIOR

A review of the literature on successful teacher behavior over the past decade presents a somewhat cloudy picture.

In 1958, for example, Brim (1958) concluded from an examination of the research literature that there were no consistent relationships between teacher characteristics and effectiveness in teaching. In the Handbook of Research on Teaching, Wallen (1963) reports that ". . . teaching methods do not seem to make much difference" and that ". . . there is hardly any evidence to favor one method over another [p. 484]." In the same book, Getzels and Jackson (1963) conclude that ". . . very little is known for certain . . . about the relation between teacher personality and teacher effectiveness [p. 574]."

In a more optimistic view, the recent "Coleman Report" (1966), Equality of Educational Opportunity, found that measures of teacher quality were significantly related to achievement and that teacher characteristics accounted for a ". . . higher proportion of variation in

achievement than did all other aspects of the school combined, excluding the student body characteristics [p. 316]." Among the teacher characteristics included were educational level and years of experience. It would appear important, then, to include these two teacher characteristics in a study involving teacher characteristics and behaviors.

Gage (1967) offered some very positive statements about successful teacher behavior at a recent Banff Conference in the Province of Alberta. In his keynote address, "Successful Teacher Behavior: Can Science Contribute to the Art of Teaching?" Gage presented three operational definitions of successful teaching behavior.

The first, "Behavior Dimension A," may be described as teacher warmth or empathy. An example of this dimension is Flanders interaction analysis categories 1 and 2 which includes: "Accepts and clarifies the feeling tone of the students in a nonthreatening manner" and "Praises or encourages student action or behavior." A second example of this dimension of teacher behavior can be measured by the responses of teachers to Cook's (1951) Minnesota Teacher Attitude Inventory. The teacher responds to such statements as "Most children are obedient," "Minor disciplinary situations should sometimes be turned into jokes," "Most pupils lack productive imagination," and "Most pupils are resourceful when left on their own." A third example is exemplified in Ryans' (1960) Teacher Characteristics Schedule in which teachers respond to a battery of items such as: "Pupils can behave themselves without constant supervision," "Most pupils are considerate of the teacher's wishes," and "Most teachers are willing to assume their share of the unpleasant tasks associated with teaching."

Gage (1967) lists a number of research studies to support

"Behavior Dimension A" and concludes:

In short, a substantial body of evidence justifies two conclusions: (a) Teachers differ reliably from one another on a series of measuring instruments that seem to have a great deal in common. (b) These reliable individual differences among teachers are, by and large, consistently related to various desirable things about teachers.

What term can be applied to the desirable end of this dimension of behaviors and attitudes? Probably the term most widely used is warmth. Teacher warmth, operationally defined as indicated above, seems--on the basis of abundant and varied research evidence--to be quite defensible as a desirable characteristic of teachers [p. 13].

The second dimension, "Behavior Dimension B," may be described as indirectness in teaching. To illustrate this dimension, Flanders' categories 3 and 4 may be used: "Accepts or uses ideas of student: clarifying, building, or developing ideas suggested by a student," and "Asks questions: asking a question about content or procedure with the intent that a student answer." Within classrooms of indirect teachers, Flanders (1965) found that there are instances of Category 8: "Student talk-response; talk by students in response to teacher. Teacher initiates the contact or solicits student statements," and Category 9: "Student talk-initiation; talk by students which they initiate." A second example of this behavior dimension is identified by Ryans' Pattern Z, reflecting, "Stimulating, imaginative, and original versus dull and routine" teacher behavior. A third example may be inferred from Shulman's (1966) symposium, Learning by Discovery which dealt with the question, "How much and what kind of guidance should the teacher provide? . . . the degree of guidance by the teacher varies from time to time along a continuum, with almost complete guidance of what the pupil must do at one extreme to practically no direction at the other [pp. 182, 183]."

Numerous studies, using the Flanders Analysis, have established

significant relationships between the dimension of indirectness and measures of student achievement in subject matter. For instance, Flanders (1960), in a two year Minnesota Study, studied the relationship between teacher influence patterns and the achievement and attitudes of junior high school students. Results indicated that: (a) students of the more direct teacher learned less as measured by written achievement than students of indirect teachers, (b) all types of students (including dependency-prone students) learned more, working with the more indirect teachers, (c) the results were similar for both mathematics and social studies, (d) teacher flexibility, used in conjunction with direct-indirect influence, was a good predictor of teaching success. Flanders (1965) described teacher flexibility as the degree to which a teacher varies his indirect-direct verbal influence to match the teaching task at hand. In his Minnesota Study, Flanders concluded that:

(1) Indirect teacher influence increases learning when a student's perception of the goal is confused and ambiguous.

(2) Direct teacher influence increases learning when a student's perception of the goal is clear and acceptable
[p. 108].

In a recent study carried out at the elementary school level, Nelson (1966) found that indirect teacher influence was positively related to pupil achievement on written language tests. She also found that direct teacher influence patterns appeared to inhibit pupil development of written language skills.

LaShier (1966) obtained similar results when working with student teachers who were teaching a six-week unit in biological science. LaShier found that pupils of indirect student teachers achieved more than did pupils of direct student teachers.

Soar (1966), in one of the largest studies yet conducted using interaction analysis, found that indirect teaching produced greater growth in reading comprehension in elementary school pupils than did direct teaching.

Powell (1968) found that children who had an indirect teacher scored significantly higher on arithmetic achievement tests than did children who had a direct teacher for the same period of time.

The research results do not suggest that there is a single pattern of teacher behavior that should be continually maintained in the classroom. There are situations in which an integrative teacher behavior pattern is less appropriate than a dominative pattern. Furthermore, it is possible that identical acts by the teacher may in one situation be perceived by pupils as dominative and in another situation as integrative.

When comparing the expository versus the hypothetical modes of teaching, Ausubel (1963) concluded that "Self-discovery methods and the furnishing of completely explicit rules . . . are relatively less effective [p. 171]." The emphasis should be on the ineffectiveness of "the furnishing of completely explicit rules."

In summarizing "Behavior Dimension B," Gage concludes that:

It seems safe to say that a reasonable use of the guided discovery method, or "indirectness," in teaching--is desirable. Teachers not sensitized to its desirability typically exhibit too little indirectness. As Flanders put it, 'our theory suggests an indirect approach; most teachers use a direct approach' [p. 14].

The third dimension, "Behavior Dimension C," may be described as teacher cognitive organization. The studies by Smith (1961), at the University of Illinois, illustrate this dimension. These studies make use of the logical steps of problem solving and draw heavily on knowledge about inductive and deductive reasoning, scientific method, procedures for

defining terms, level of abstraction, and principles from the field of semantics. Along this same vein, other researchers express similar ideas: Ausubel (1963) speaks of "relevant ideational scaffolding;" and "cognitive structure;" Bruner (1966) also deals with "cognitive structure;" Gagne (1965) describes "learning structure;" and Hickey and Newton (1964) define a "logic tree."

Gage describes "Behavior Dimension C" as:

The implications of such instructional research for the behavior of the live teacher in the classroom seem clear: if curricular materials should exhibit a valid cognitive organization, so should the behavior of the teacher. At the close of his study of social-interaction variables in teaching, Flanders offered the observation that, 'there is no substitute for knowledge of what is being taught [p. 15].'

From the foregoing descriptions of effective teacher behavior a few additional comments may be made. First, all teachers exhibit these three behavioral dimensions to a greater or lesser extent in their day-to-day teaching activities. Furthermore, these dimensions should not be thought of as distinct or mutually exclusive. Also, it is implied that the more successful teachers are those who exhibit a higher rating on each of the three categories. And finally, for the purpose of this study, Flanders interaction analysis will be considered an adequate measure of "Behavior Dimensions A and B."

In conclusion, there appear to be a number of factors and measurements which might well be involved in a study concerned with effective teaching behaviors and the relation of those behaviors with pupil growth in the inquiry skills of science:

1. Teacher experience and science background.
2. Teacher warmth or empathy (as measured by Flanders' categories 1 and 2).

3. Indirectness in teacher-pupil verbal interaction patterns (as measured by Flanders' categories 3 and 4) compared with directness in teacher-pupil verbal interaction patterns (as measured by Flanders' categories 5, 6, and 7).
4. Teacher flexibility of verbal influence (as measured by the range of verbal interaction patterns that a teacher exhibits during a variety of classroom activities).

If research indicates that an indirect and flexible teacher has pupils who achieve higher in subject content, why should not these same teacher behaviors cause pupils to achieve higher in inquiry skills in science?

INQUIRY IN ELEMENTARY SCIENCE

There has been considerable interest in new science programs during the past ten years. Many of these programs stress the development of inquiry skills.

The American Association for the Advancement of Science (AAAS) established a Commission on Science Education which is preparing a new program entitled Science - A Process Approach (1965).

The forward to the teachers' guide contains the following:

The early parts of Science - A Process Approach, developed by the AAAS Commission on Science Education, provide instruction in science for the primary grades which emphasizes the development of competence in skills basic to further learning. These processes are called Observing, Recognizing and Using Number Relations, Measuring, Recognizing and Using Space/Time Relations, Classifying, Communication, Inferring, and Predicting [p. 7].

At the level of grades 4 and 5, integrated processes are used. These are rooted in the simple processes developed during the primary grades. The integrated processes are: formulating hypotheses, making operational

definitions, controlling and manipulating variables, experimenting, interpreting data, and formulating models.

It may be hypothesized that a teacher can influence, via teacher-pupil verbal interaction, the development of the inquiry skills in science, such as: observing, recognizing and using number and space/time relations, classifying, communicating, inferring, predicting, formulating hypotheses, making operational definitions, interpreting data, and formulating models.

The Curriculum Guide states that these process skills are basic intellectual activities that ". . . are developed and used as they are required by the student to gain and process data in order to develop concepts [p. 10]." The purpose, then, of the development of the process skills in the new science curriculum is to use these tools of inquiry to further grasp and understand the basic scientific concepts. This appears to be somewhat of a limited view of the value of developing the inquiry skills.

Many noted psychologists, scientists, and educators have stressed the importance of developing inquiry skills for their own sake. In a lecture entitled, "The Teaching of Science as Enquiry," Schwab (1962) stresses the importance of inductive modes of inquiry in the teaching of science. Gagne (1963), of the American Institute for Research in the Behavioral Sciences, strongly influenced the AAAS curriculum design; a design which stresses the development of inquiry skills, per se. Stendler (1965), in writing about Piaget's developmental theory of learning, suggests that ". . . children, as they study subject-matter, should be alerted to process in terms of the logical operations (Piaget's) . . . [p. 344]." Bruner (1961), in the article "The Act of Discovery," describes four major benefits derived by children when they learn how to

investigate and discover for themselves: (a) an increase in intellectual potency, (b) a shift from extrinsic to intrinsic rewards, (c) a learning of the heuristics of discovery, and (d) an aid to memory processing.

During the past decade a host of studies have examined various approaches toward the effective teaching of the inquiry skills in science. However, two main approaches permeate the research: (a) the discovery or hypothetical mode as described by Bruner (1961), and (b) the discrepant event-responsive environment approach as created by Suchman (1960).

Bruner (1961) distinguishes between the hypothetical or discovery mode and the expository mode of teaching:

In the former (expository mode), the decisions concerning the mode and pace and style of exposition are principally determined by the teacher as expositor; the student as listener In the hypothetical mode, the teacher and the student are in a more co-operative position with respect to what in linguistics would be called 'speaker's decisions.' The student is not a bench-bound listener . . . [p. 23].

In the hypothetical mode the teacher strives to develop inquiry skills by providing for the active involvement of the pupils in questioning, hypothesizing, making operational definitions, interpreting data, and formulating models. This approach may be contrasted with the expository mode whereby the teacher tends to present science concepts and process skills in the form of a lecture. Exposition tends to be a one-way process of communication.

A number of studies have attempted to establish significant relationships between the hypothetical or discovery mode of teaching science and improved pupil development of science concepts and inquiry skills. Scandura (1963), for example, found conflicting results when he attempted to identify the relative value of the hypothetical and expository modes of instruction in the teaching of elementary school

science. Scandura states that the conflicting results obtained were largely attributed to variations in the timing of the guidance given relative to the level of student readiness. The question may be raised: Would indirect and flexible teaching (as defined by Flanders) used in conjunction with the hypothetical mode of teaching have produced significant and consistent results in Scandura's study?

Carpenter (1963) tested textbook recitation versus problem-solving methods in teaching science. Although the pupils learned factual material more readily in the problem-solving approach, no conclusions were reached about the development of inquiry skills in science.

Bennett (1965) compared the experimental-field (hypothetical) method and the traditional classroom method of teaching elementary science. The field method did not statistically prove to be better than the traditional classroom method in: (a) the development of science content and processes in ecological biology, and (b) the development of favourable pupil attitude toward science and scientists.

The results of these and other contemporary research appear only partially supportive of Bruner's hypothetical mode as opposed to the expository mode of teaching. There appears to be a need for other avenues of investigation to provide teachers with research support for their daily teaching tasks.

Of the many studies devoted to the inquiry or process aspect of elementary school science, none has stirred more interest than that of Suchman (1960). He believed that pupils could be taught to attack, through a series of "yes" or "no" questions, a scientific concept posed by a silent science film-loop. Suchman concludes from his research that

fifth-grade pupils can become more productive in their use of questions. There are important parallels in Suchman's technique and Flanders' indirect-direct hypothesis. Flanders' categories 3 and 4 (uses the ideas of students and asks questions of students) appear to reflect Suchman's method. It may be stated that Suchman's technique reflects certain categories of Flanders' analyses.

A number of researchers have used the Suchman inquiry training technique. Butts and Jones (1966), for example, used this technique with sixth-grade children as the vehicle of instruction in a study to discover whether or not children exposed to such guidance evidenced improved problem-solving behavior. The researchers found a relationship between inquiry and positive changes in problem-solving behavior, but no evidence to support the assertion that concept development results from inquiry training. Scott (1966) studied fourth-, fifth-, and sixth-grade pupils. He found that inquiry training seemed to encourage exploratory thought, creativity, and a seeing of relationships not always observable in conventional instruction. Weigand (1966), using the Suchman technique, studied the significance in inquiry development of the teacher's ability to determine the relevancy of children's questions. The results indicate that: (a) the more effective teacher uses the ideas and questions of pupils (this reflects Flanders' category 3), and (b) teachers can improve their ability to ascertain the relevancy of children's questions.

The Curriculum Guide offers suggestions to teachers concerned with developing inquiry skills in pupils. For example, teachers should develop the art of questioning. Convergent as well as divergent questioning techniques are essential. Bloom (1956) has edited a cognitive taxonomy of educational objectives which includes: (a) knowledge,

(b) comprehension, (c) application, (d) analysis, (e) synthesis, and (f) evaluation. A teacher fluent in the use of this taxonomy and who applies these criteria to questioning techniques can improve the verbal interaction climate within the classroom.

A teacher who uses divergent questions and questions requiring students to analyze, synthesize, and evaluate will have interaction matrices that reflect this characteristic. (Flanders' interaction category 4 reflects the teacher questioning factor.) It may be hypothesized that the class means in achievement in inquiry skills of pupils experiencing this type of classroom atmosphere will be higher.

The Curriculum Guide (1968) states:

The work of Suchman at the University of Illinois is an excellent verification of the belief that children can prepare and test hypotheses. There is no dearth of opportunity for training in good habits of logical thought if children are not restricted to dull memorization of the textbook. Children should have numerous opportunities to predict the results of a particular action. Do not supply the answer in advance, nor allow children to turn to authority before their own analytical schemes are found wanting or before additional verification is required. Continue to ask, 'Why? How do you know? How can we test this? Are you sure? How can we find out? What will happen if we do what you say? What do we need in order to do it? Where can we find out? What do we do next?'

A permissive classroom atmosphere must prevail which encourages both children and teacher to examine the evidence they find, to assess their hypotheses, and to come to the most reasonable and logical interpretations of the data consistent with the evidence [p. 21].

The "permissive classroom atmosphere" may be reflected in Flanders indirect influence. The research (already reported under the subject of Effective Teaching) indicates that there is a positive relationship between indirect teacher influence and pupil achievement in content areas. Why should not the same results occur in pupil achievement in inquiry in science?

There do not appear to be any studies in the literature linking teacher indirect-direct influence and achievement in inquiry skills in science. This thesis will attempt to study that relationship.

Within most science classrooms there is a variety of activities which occur--teacher-lecturing, student independent experimentation, teacher demonstration of experiments, student silent reading, supervised seatwork, teacher introduction of new material. Does the teacher exhibit a variety of influence during these various activities? Is she more indirect when introducing new material? Less direct when student goals are clear? Does the teacher adapt her pattern of influence to meet the different types of activities? Identifying activity periods is a second system of categorization that may be superimposed on the system for classifying verbal statements. Teacher flexibility may then be defined as a measure of the change a teacher makes in his verbal influence from one type of activity to another. It may be hypothesized that the more flexible teacher will have pupils who achieve higher in inquiry skills in science. Previous researchers have gathered interaction data on an intermittent basis, i.e., not sequentially, day by day. A continuous observation might reflect teacher flexibility more accurately.

SUMMARY

The study of the development of inquiry skills in pupils has generally been restricted to methods of teaching, such as: (a) the discovery or hypothetical method as described by Bruner, and (b) Suchman's inquiry training technique. The research results fail to indicate one consistently effective teaching method; it might even be stated that the research results are inconclusive. None of the studies,

cited in this chapter, has utilized interaction analyses in conjunction with teaching methods.

Considerable research, at the elementary and secondary levels, indicate that pupils achieve higher in a variety of content areas as a result of indirect and flexible teaching. The main question raised in this study is: Is there a significant relationship between indirectness and flexibility in teaching and pupil achievement in inquiry in elementary school science? Perhaps an investigation of teacher behaviors, namely, teacher-pupil verbal interaction, may reveal more consistent supportive findings for the effective teaching of inquiry skills. At the very least, such findings may suggest that interaction analysis should be used in conjunction with various teaching methods for the development of inquiry skills.

Any study involving teacher behaviors should take into account teacher experience and background.

A number of concomitant questions evolve from the main question about teacher-pupil verbal interaction and pupil achievement in inquiry in science:

1. Does an indirect teaching approach affect boys and girls to the same extent?
2. Does an indirect teaching approach affect pupils of higher IQ to the same extent as it does pupils of lower IQ?
3. Do teachers who are classified as indirect exhibit more flexible verbal interaction patterns than do those teachers classified as direct?

CHAPTER III

EXPERIMENTAL DESIGN AND STATISTICAL PROCEDURES

OVERVIEW

The questions raised at the end of Chapter II were predictions of higher or lower pupil achievement in inquiry skills according to either indirect or direct verbal interaction patterns of teachers. In this study teacher behavior was considered the independent variable and pupil achievement in inquiry skills the criterion measure.

In this field experiment, in which the spontaneous behavior of the eight regularly employed teachers was observed, data were collected to test whether or not the particular conditions necessary to test the hypotheses did in fact exist. Eight steps were involved in determining whether the teachers' behaviors differed significantly.

- Step 1: Collection of Flanders Interaction Analysis data for each of the eight teachers. (Appendix A)
- Step 2: Preparation of an interaction matrix for each teacher using all data collected. (Appendix H)
- Step 3: Calculation of I/D ratio for each teacher from that teacher's matrix. (Appendix H)
- Step 4: Classification of each teacher, using the I/D ratio, as either indirect, average, or direct. (Appendix H)
- Step 5: Preparation of a composite matrix for the three teachers classified as indirect (Table VI).
- Step 6: Preparation of a composite matrix for the three teachers classified as average (Table VII).

Step 7: Preparation of a composite matrix for the two teachers classified as direct (Table VIII).

Step 8: Comparison of the composite matrix for the indirect teachers with the composite matrix for the direct teachers using Darwin's chi-square test. (Appendix F)

THE SAMPLE

The population under study consisted of all the grade six teacher-class units within the Edmonton Separate School District, Number 7, using the new elementary science program. Of the total of fifty-six Separate elementary schools, twenty-three were using the new science program.

TABLE I
CLASSIFICATION OF PUPILS BY SEX
AND BY TEACHER

Teacher Code Number	Boys	Girls	Pupils
101	21	17	38
102	14	20	34
103	17	12	29
104	12	16	28
105	15	13	28
106	18	16	34
107	17	13	30
108	14	24	38
Totals	128	131	259

The target population, then, consisted of approximately fifty teacher-class units. The sample consisted of a random selection of eight classes from the target population. By randomly selecting the teachers for study, it was hoped that a significantly wide range of

teacher verbal influence would appear in the sample.

An investigation into the science background of the eight classes revealed that each of the classes had identical science curricula in the years prior to the introduction of the new science curriculum in September, 1968.

The pupils sampled may be classified as urban. There were 128 boys and 131 girls, giving a total of 259 pupils. Table I provides a classification of pupils by sex according to teacher-pupil group.

TABLE II
RANGE, MEAN, AND STANDARD DEVIATION OF
INTELLIGENCE AND SCIENCE ACHIEVEMENT

Measure	Teacher Code Number	Range	Mean	SD
IQ*	101	91-136	115.90	12.46
	102	83-139	114.18	13.11
	103	76-136	105.93	16.46
	104	88-138	114.86	13.02
	105	82-136	109.21	14.56
	106	88-143	116.18	12.37
	107	89-141	115.53	12.43
	108	79-135	106.42	12.33
Totals		79-143	112.32	13.93
STEP*	101	35-53	46.03	4.56
	102	26-56	44.62	5.53
	103	21-52	41.28	7.23
	104	31-52	43.79	5.00
	105	19-48	38.21	7.98
	106	25-51	43.50	5.61
	107	29-53	47.03	4.90
	108	25-51	41.45	6.15
Totals		19-56	43.34	6.46

* See page 30 for a description

Table II represents the range, mean, and standard deviation (SD) of intelligence and science achievement scores for the pupils by class. The mean IQ for the total sample of pupils was 112.32; the range, 79-143; and the SD, 13.93. The mean science achievement (STEP) score for the total sample of pupils was 43.34; the range, 19-56; and the SD, 6.46.

Teacher Characteristics

Data were collected from each teacher pertaining to: (a) number of years of teaching experience, (b) number of university-level science courses (including methods courses). Table III summarizes the teacher sample in terms of these two teacher characteristics. The number of years of teaching experience varied from 1 to 38. The teachers varied in the number of university science courses taken from 1 to 11.

TABLE III
TEACHING EXPERIENCE AND SCIENCE
BACKGROUND OF TEACHER

Teacher Code Number	Teaching Experience, Years	University Science Courses, Number
101	8	3
102	9	4
103	8	1
104	6	11
105	1	5
106	9	8
107	38	0
108	15	3

INSTRUMENTATION

Pupil Intelligence Quotient

Each of the 259 pupils in the sample population was tested in the Fall of 1968 using the Otis Alpha intelligence test. This testing was part of the Separate school system's annual testing program. The pupils' intelligence quotients (IQ) were collected from the files of each of the eight schools.

Sequential Test of Educational Progress - Science

The Sequential Test of Educational Progress - Science test, Form 4A (STEP), was administered by the writer in May, 1969, to each of the eight classes. (Appendix D)

STEP tests were first prepared in 1956 and cover levels 1 (grades 13-14), 2 (grades 10-12), 3 (grades 7-9), and 4 (grades 4-6). The STEP science test contains two parts. Each part consists of thirty questions, including measures of inquiry skills. The Manual for Interpreting Scores (1956) lists six areas of process skills tested:

1. Ability to identify and define scientific problems. Included in this category is the ability to isolate a problem from a mass of given material and to formulate the problem in a way which allows for systematic solution.
2. Ability to suggest or screen hypotheses. Sub-abilities included here are the abilities to suspend judgment, recognize cause-and-effect relationships, recognize the possibility of testing a hypothesis, recognize the logical consistency and plausibility of a hypothesis, and check it with relevant laws, facts, operations, or experiments.
3. Ability to select valid procedures. This encompasses the design of experiments and the planning required for collection of appropriate data.
4. Ability to interpret data and draw conclusions. This includes the ability to formulate valid conclusions and to recognize or draw valid generalizations from data known or given.

5. Ability to evaluate critically claims or statements made by others. This encompasses the critical evaluation of advertisements, written materials, and audio-visual materials. Other abilities included are the abilities to detect superstition and fancy, recognize the pseudoscientific, and avoid unwarranted extrapolations and generalizations; to distinguish fact, hypothesis, and opinion; and to distinguish the relevant from the irrelevant.
6. Ability to reason quantitatively and symbolically. Included under this heading are abilities to understand and use numerical operations, symbolic relations, and information presented in graphs, charts, maps, and tables.

For each of the Science tests the approximate percentages of questions designed to probe each of the abilities are as follows:

Define problems	10%	
Screen hypotheses	25%	
Select procedures	17%	
Draw conclusions	23%	
Evaluate claims	12%	
Reason quantitatively	13%	[p. 7]

This manual gives directions for administering, scoring, and interpreting scores. Reliability and validity statistics are also listed.

A perusal of the methods of inquiry for the new science curriculum (Appendix C), the STEP science test (Appendix D), and the six areas of process skills just quoted reveals that the STEP test is a reasonable measure of inquiry skills. (Before selecting an instrument to measure the inquiry skills, the writer corresponded with Butts of the University of Texas. Butts (1966) stated that his TAB science test, which measures inquiry skills, was in the process of being improved and, therefore, not available for use. Butts recommended the use of the STEP test.)

Flanders Interaction Analysis

Flanders interaction analysis (1966) was used to determine teacher-pupil verbal interaction patterns. (Appendix A) Interaction analysis data were collected during the months of February, March, and April, 1969. The science lessons of each of the eight teachers were observed for a

continuous period of at least one week. Each teacher was aware, beforehand, of all forthcoming classroom visits. It was hoped, as a result, that the observed science lessons more closely typified the optimum teacher-pupil verbal interaction patterns than if visits had been unannounced and random in nature.

The presence of an outside observer could have affected the verbal interaction patterns. The writer found that, generally, by the second visit a stable interaction pattern had evolved. Because of the "required adjustment period" all interaction data collected from the first visit to each teacher were ignored.

Observer training and reliability of observation were problems treated in the following manner.

1. Using the training tapes and materials prepared by Amidon and Flanders (1967), the writer and one outside observer became relatively proficient in the observation and recording of interaction data. This training period lasted approximately twenty hours over a period of three weeks.

2. Teacher-pupil interaction data were collected by the writer in the classroom setting.

3. Sample classroom observations were recorded on tape.

4. The writer prepared a second set of data of the teacher-pupil interaction from this tape recording.

5. The outside observer prepared a second set of data from the teacher-pupil interaction from this tape recording.

6. Spot tape recordings were made during the three-month (February to April) data collection period.

7. Scott's coefficient of reliability was calculated. In no case did the reliability fall below 0.90. (Appendix E)

Marking Classroom Activities

All classroom activities were classified into one of five mutually-exclusive categories:

- i) Routine administrative matters (sharpening pencils, settling down, cleaning-up, returning papers, administrative details).
- ii) Discussion of new material (teaching science material new to students).
- iii) Discussion of previously learned material (oral review, recapitulation).
- iv) Laboratory science activities (students performing and demonstrating experiments, teacher supervising individuals).
- v) All other activities.

The identification of classroom activities constituted a second system of categories that were superimposed on the ten Flanders' categories.

During the collection of classroom interaction data, the writer drew a double line under the tallies whenever there was a change in the class formation, the communication pattern, or in the classroom activity. After the classroom visit was completed, the observer used the double lines and marginal notes to classify the classroom activities.

For each teacher interaction matrices were prepared for: (a) a combination of the tallies for classroom categories i) and iii); (b) a combination of tallies for classroom categories ii) and iv); (c) a combination of all tallies for all five classroom categories. For each teacher, I/D ratios were calculated for each of the three matrices. (For the combination matrices and calculations of I/D ratios, see Appendix G.)

Teacher Flexibility

Research suggests (Flanders, 1965) that teachers are more effective if they exhibit more indirect influence on pupils when new material is being presented. Conversely, as students begin to develop skills, competence, and interest in the curriculum content, the more effective teacher tends toward more direct influence. In other words, the more effective teacher is the one who exhibits a greater variety of appropriate verbal influence.

Table IV summarizes the I/D ratios for each teacher for: (a) a teacher's combination matrix for categories i) and iii), (b) the teacher's combination matrix for categories ii) and iv). The teacher's flexibility score was found by subtracting (a) from (b), above. One

TABLE IV
I/D RATIO FOR CLASSROOM CATEGORIES
i) AND iii), ii) AND iv), AND
TEACHER FLEXIBILITY

Teacher Code Number	a = I/D for Classroom Cat. i), iii)	b = I/D for Classroom Cat. ii), iv)	Flexibility = b - a
101	0.465	1.377	0.912
102	0.459	0.661	0.202
103	0.970	1.153	0.183
104	1.709	1.872	0.163
105	0.629	0.307	(-0.322)
106	0.487	0.945	0.458
107	0.869	1.584	0.715
108	0.289	0.548	0.259

stipulation was made--the range was considered positive if the I/D ratio for classroom activities ii) and iv) was larger than the I/D ratio for categories i) and iii). Conversely, the range was considered negative

if the I/D ratio for classroom activities ii) and iv) was smaller than that for classroom activities i) and iii).

CLASSIFICATION OF TEACHERS

Classifying Teachers by I/D Ratios

The I/D ratios of the eight teachers varied from a low of 0.443 to a high of 1.885. The natural dividing lines for creating the three groups of teachers, i.e., indirect, average, and direct, appeared to be 0.500 and 1.000. In other words, an indirect teacher was selected as one whose I/D ratio was greater than 1.000; a direct teacher as one whose I/D ratio was less than 0.500. Table V represents the resultant grouping of the eight teachers.

TABLE V

CLASSIFICATION OF TEACHERS BY I/D RATIO *

Assignment	Teacher Code Number	I/D Ratio
INDIRECT	101	1.009
	104	1.885
	107	1.194
AVERAGE	102	0.569
	103	0.996
	106	0.628
DIRECT	105	0.429
	108	0.443

* See Appendix H for details

Teachers 101, 104, and 107 were classified as indirect; teachers 102, 103, and 106, as average; teachers 105 and 108, as direct.

The classification of teachers 101 and 103 was somewhat of a problem. Although these two teachers had I/D ratios which were almost

equal, 1.009 compared with 0.996, a study of each teacher's flexibility score assisted in the categorization decision. Teacher 101 had a flexibility score of 0.912 whereas teacher 103 had a flexibility score of 0.183. Because teacher 101's flexibility score was much higher than that for teacher 103, the decision was made to categorize teacher 101 as indirect. Teacher 103 was categorized as average.

Creating and Comparing the Composite Matrices

Having classified the teachers into three main groups, a study was then made into the nature of the differences between the indirect and direct teachers. To accomplish this task three composite matrices were prepared. The first composite matrix (Table VI) was created by adding together, cell-by-cell, the combined matrices for teachers 101, 104, and 107. (These three combined matrices appear in Appendix G on pages G-1, G-4, and G-7.) The second composite matrix (Table VII) was created from the combined matrices for teachers 102, 103, and 106. And finally, the third composite matrix (Table VIII) was created from the combined matrices for teachers 105 and 108. Since the composite matrices were reduced to percentage figures, the three matrices were directly comparable.

The first comparison made among the three imaginary teachers concerned the relative time each teacher spent in each of the ten Flanders' categories. By comparing the column totals, expressed in per cent, a histogram was prepared (Figure 2).

Figure 2 shows that there was a higher number of tallies in categories 1, 2, and 3 and a lower number of tallies in categories 6 and 7 for the indirect teachers. This finding was consistent with the findings of Flanders' Minnesota Study (1965) as illustrated in Figure 3

TABLE VI
INTERACTION MATRIX FOR INDIRECT
TEACHERS, N = 3; EXPRESSED AS PER CENT

	1	2	3	4	5	6	7	8	9	10
1	0.03	0.02	0.00	0.05	0.00	0.02	0.02	0.02	0.03	0.06
2	0.00	0.03	0.10	3.85	1.28	0.24	0.28	0.19	0.89	0.57
3	0.00	0.00	1.39	1.55	0.50	0.17	0.09	0.74	0.42	0.20
4	0.07	0.03	0.15	2.59	0.75	0.37	0.35	8.50	7.06	0.93
5	0.00	0.05	0.13	4.10	8.40	0.92	0.10	0.13	1.43	0.59
6	0.00	0.07	0.06	0.80	0.55	1.52	0.40	0.28	0.65	0.72
7	0.02	0.08	0.09	1.30	0.71	0.52	0.53	0.17	0.32	0.44
8	0.11	3.25	0.55	3.65	0.99	0.59	0.78	2.13	0.17	0.44
9	0.00	3.76	1.75	2.27	1.75	0.29	0.89	0.00	7.66	1.01
10	0.00	0.12	0.10	1.88	1.78	0.77	0.69	0.52	1.41	2.07
Total	0.23	7.41	4.32	22.05	16.71	5.41	4.13	12.68	20.04	7.03 100.00

Total Number of Tallies = 5933

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{34.00}{26.25} = 1.295$$

Per cent Teacher Talk = Column 1-7 = 60.25%

Per cent Pupil Talk = Column 8-9 = 32.72%

Per cent Silence = Column 10 = 7.03%

TABLE VII
INTERACTION MATRIX FOR AVERAGE TEACHERS,
N = 3; EXPRESSED AS PER CENT

	1	2	3	4	5	6	7	8	9	10	
1	0.09	0.00	0.00	0.08	0.12	0.08	0.00	0.03	0.00	0.00	
2	0.06	0.05	0.13	1.51	1.92	0.23	0.18	0.15	0.85	0.22	
3	0.00	0.00	0.89	1.37	0.68	0.05	0.07	0.00	0.32	0.16	
4	0.00	0.06	0.10	2.24	1.19	0.29	0.22	8.68	4.15	0.75	
5	0.06	0.16	0.22	5.02	13.69	1.94	0.47	0.15	3.39	1.50	
6	0.08	0.08	0.06	0.47	1.08	2.69	0.23	0.23	0.95	1.38	
7	0.00	0.07	0.10	0.92	0.60	0.42	0.25	0.19	0.72	0.40	
8	0.07	2.91	0.55	3.13	1.26	0.22	0.84	0.08	0.16	0.66	
9	0.00	2.22	1.42	1.75	4.36	0.60	1.01	0.00	2.84	2.08	
10	0.06	0.00	0.06	0.88	1.88	0.83	0.28	0.39	2.87	2.15	
Total	0.42	5.55	3.53	17.37	26.78	7.35	3.55	9.90	16.25	9.30	100.00

Total Number of Tallies = 5523

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{26.87}{37.68} = 0.713$$

Per cent Teacher Talk = Column 1-7 = 64.55%

Per cent Pupil Talk = Column 8-9 = 26.15%

Per cent Silence = Column 10 = 9.30%

TABLE VIII
INTERACTION MATRIX FOR DIRECT TEACHERS,
N = 2; EXPRESSED AS PER CENT

	1	2	3	4	5	6	7	8	9	10.	
1	0.15	0.00	0.00	0.16	0.55	0.16	0.00	0.00	0.04	0.00	
2	0.00	0.00	0.04	1.42	1.26	0.19	0.23	0.12	0.33	0.37	
3	0.00	0.00	0.43	0.54	0.35	0.04	0.08	0.00	0.07	0.12	
4	0.08	0.00	0.07	1.73	1.38	0.31	0.27	5.94	2.64	1.23	
5	0.39	0.33	0.08	3.97	22.48	1.69	0.67	0.07	2.12	2.88	
6	0.08	0.00	0.00	0.57	1.20	1.92	0.31	0.27	0.29	1.61	
7	0.03	0.12	0.00	0.99	1.17	0.15	1.01	0.19	0.52	1.18	
8	0.08	2.63	0.27	1.02	1.09	0.27	0.84	0.70	0.11	0.58	
9	0.12	0.83	0.65	1.63	2.30	0.63	1.19	0.00	1.31	1.20	
10	0.12	0.07	0.08	1.55	2.94	0.93	0.71	0.26	2.42	6.88	
Total	1.05	3.98	1.62	13.58	34.72	6.29	5.31	7.55	9.85	16.05	100.00

Total Number of Tallies = 4395

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{20.23}{46.32} = 0.437$$

Per cent Teacher Talk = Column 1-7 = 66.55%

Per cent Pupil Talk = Column 8-9 = 17.40%

Per cent Silence = Column 10 = 16.05%

and with the findings of the 1957 New Zealand Study as illustrated in Figure 4. In addition, indirect teachers exhibited a higher number of tallies for categories 4, 8, and 9 and a lower number for category 10. Again, these findings were consistent with previous research. Finally, indirect teachers showed a lower number of tallies in category 5. This finding was consistent with the New Zealand Study but not with the Minnesota Study. In addition, the direct teachers lectured a greater proportion of the time and students talked less. More time was also noted for periods of silence and/or confusion in the direct classes.

Other parts of the matrices indicated that a greater amount of class time was taken by the indirect teachers to clarify, develop, and make more frequent use of pupil ideas. (Table IX presents a comparison of cell frequencies for the matrices of indirect versus direct teachers. The data reflects the information in Tables VI and VIII.) The column 3 total for the indirect teacher was 4.32 (Table VI) whereas it was 1.62 (Table VIII) for the direct teacher. The instances of the use of category 3 was not only more numerous in indirect classes (compare column 3) but occurred for longer periods of time (compare cells 3-3). The ratio between indirect and direct teachers for this cell was 1.39 to 0.43 or greater than 3 to 1.

The frequencies in the 4-4 cells revealed that the indirect teachers used questions differently from the direct teachers. Indirect teachers not only asked more questions, by a ratio of about 2 to 1, but asked longer questions.

Sustained criticism or lengthy justification of the teacher's use of authority is recorded in the 7-7 cell. These frequencies were twice as high in the direct teachers' classrooms. Furthermore, the 6-6 cells

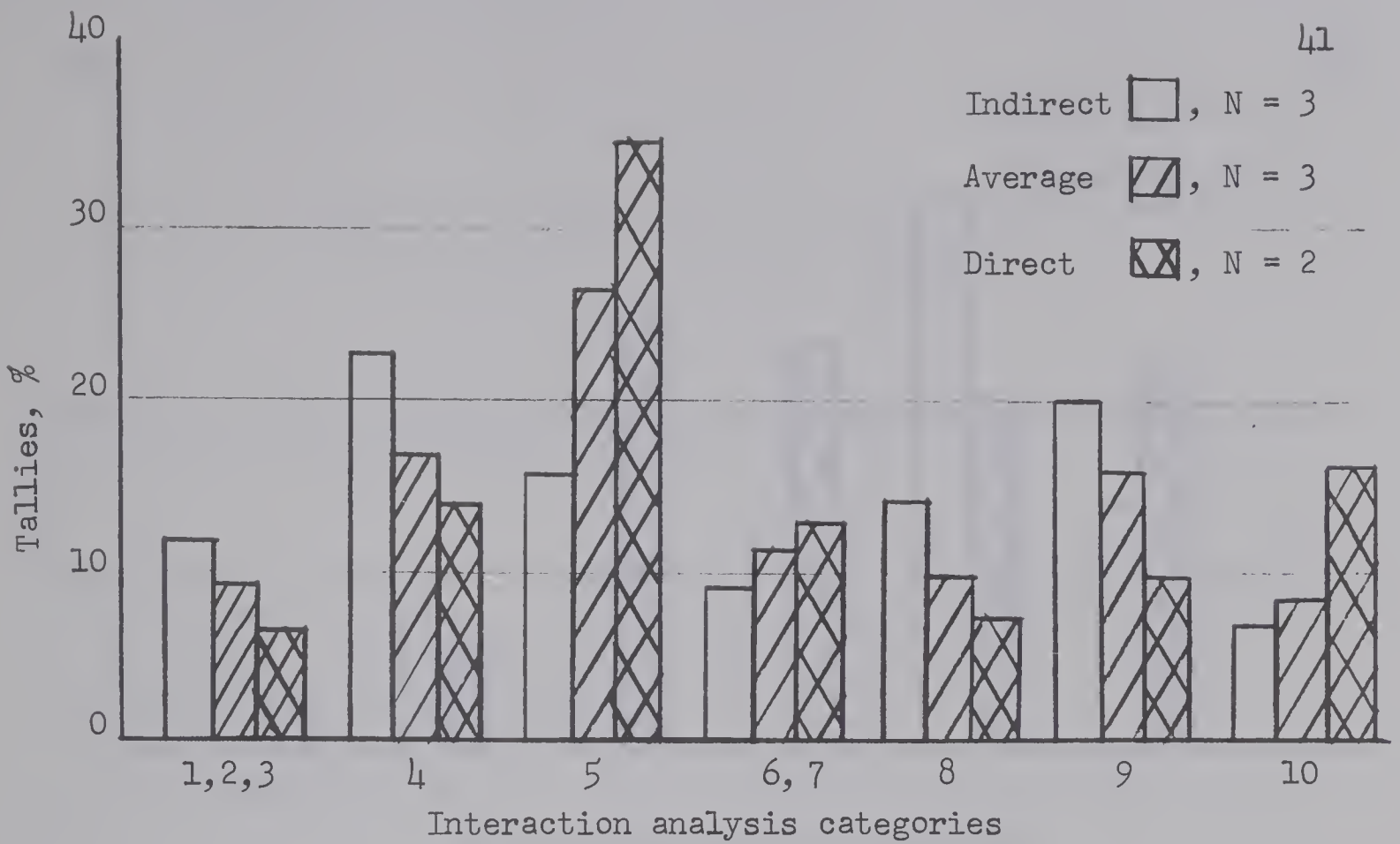


FIGURE 2

Influence Patterns of Indirect, Average, and
Direct Sixth-Grade Science Teachers

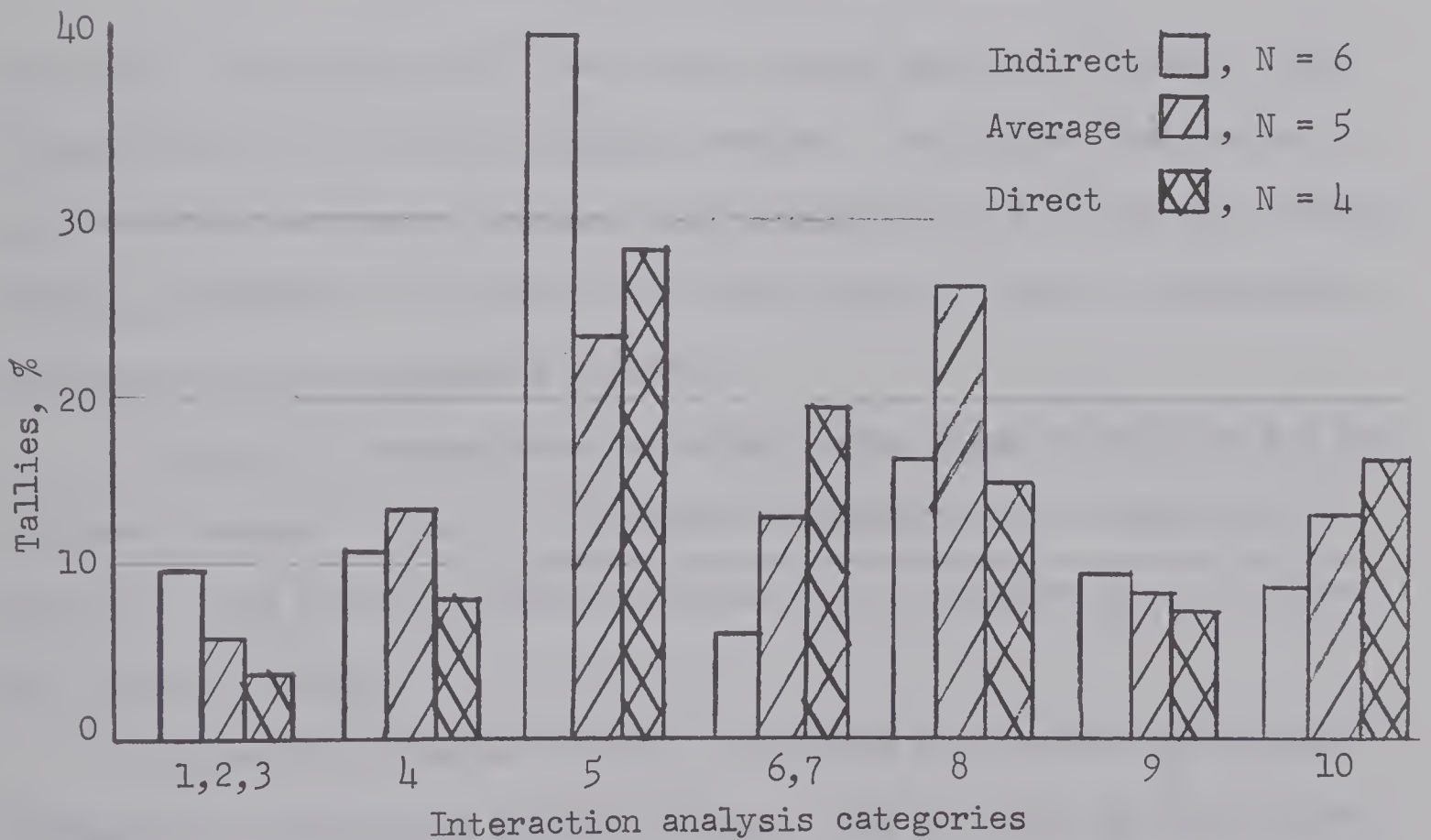


FIGURE 3

Influence Patterns of Indirect, Average, and Direct
Seventh-Grade Social Studies Teachers; Minnesota

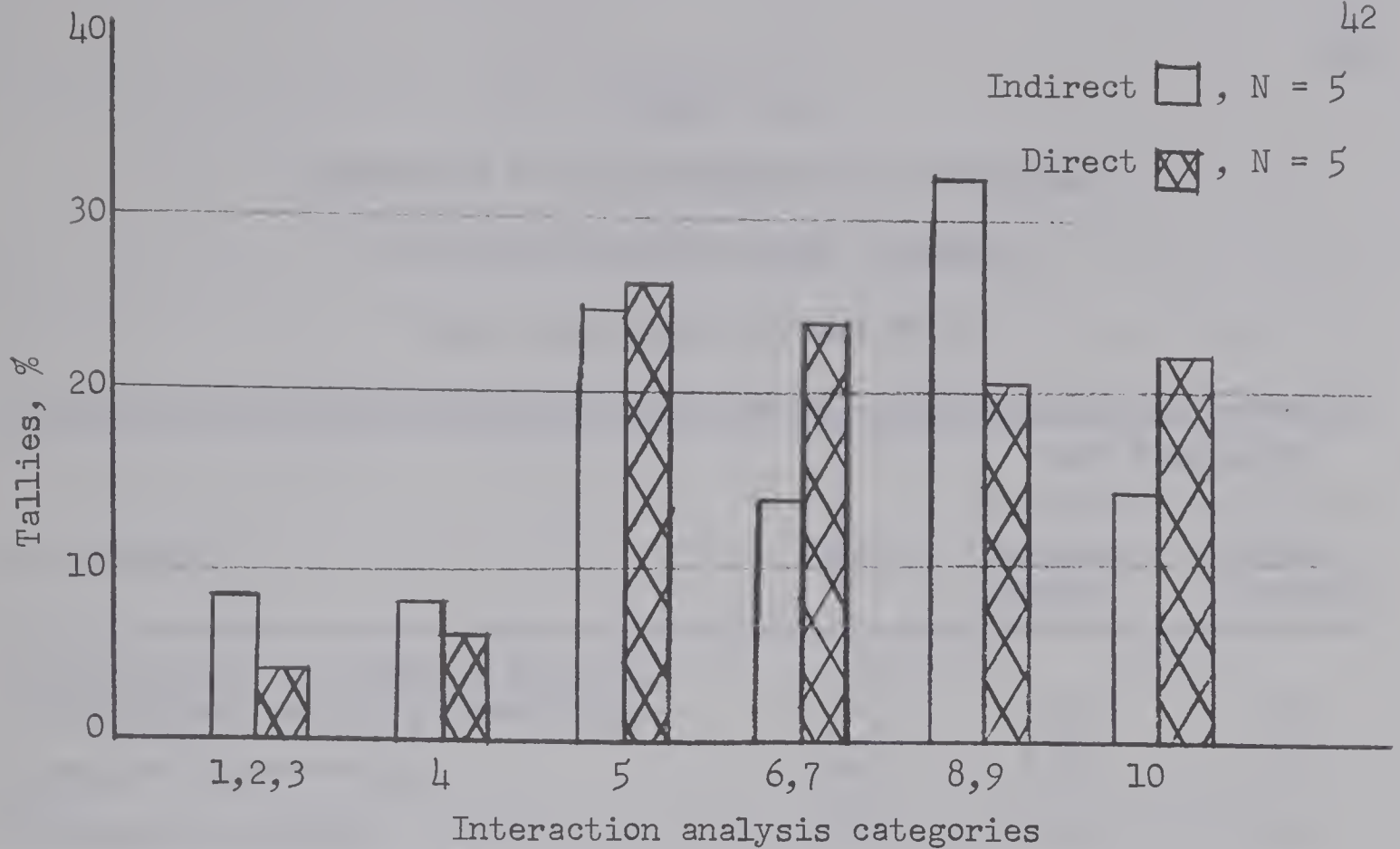


FIGURE 4

Influence Patterns of Indirect and Direct

Standard Four Teachers; New Zealand

show that the directions of the direct teacher were more lengthy; 1.92 compared with 1.52 for the indirect teacher. The higher frequencies in cell 6-9 for the direct teacher, 0.29 compared with 0.65 for the indirect teacher, indicated that pupils initiated ideas of their own rather than complying with the teacher's request.

The direct teacher lectured almost three times as much as did the indirect teacher. This is illustrated by comparing the frequencies of cell 5-5. The direct teacher's total was 22.48 compared with 8.40 for the indirect teacher.

Comparison of cells 8-8 and 9-9 offered some marked differences between the indirect and direct teachers. The 9-9 cell, in particular, showed a ratio between indirect to direct of 7.66 to 1.31. In other words, the pupils in the indirect teacher's classroom exhibited six

TABLE IX
COMPARISON OF CELL FREQUENCIES OF MATRICES
OF INDIRECT VERSUS DIRECT TEACHERS
(Data from Tables VI and VIII)

Description	Cell	Cell Frequency	
		Indirect Teacher	Direct Teacher
Sustained use of ideas of student, clarifying, building, developing	3-3	1.39	0.43
Sustained questioning	4-4	2.59	1.73
Sustained lecturing	5-5	8.40	22.48
Sustained giving of directions, commands, or orders	6-6	1.52	1.92
Sustained criticizing	7-7	0.53	1.01
Sustained pupil talk (response)	8-8	2.13	0.70
Sustained pupil talk (initiated)	9-9	7.66	1.31
Sustained silence or confusion	10-10	2.07	6.88
Pupil initiated response to teachers questioning	4-9	7.06	2.64
Silence following cessation of teacher lecturing	5-10	0.59	2.88
Student initiated discussion following teacher's directions	6-9	0.65	0.29
Teacher encouragement following pupil response	8-2	3.25	2.63
Teacher's use of ideas of pupil following pupil response	8-3	0.55	0.27
Teacher encouragement following pupil initiated discussion	9-2	3.76	0.83
Teacher's use of ideas of pupil following pupil response	9-3	1.75	0.65

times as much sustained, pupil-initiated talk.

Table IX also shows a marked difference between the two teachers for cell 5-10. Silence or confusion following teacher lecturing occurred almost five times as often in the direct classroom (even considering the fact that the direct teacher lectured almost three times as much as did the indirect teacher).

In viewing cells 8-2, 8-3, 9-2, and 9-3 it was revealed that the indirect teacher tended to encourage pupils more and use the ideas of pupils more following pupil talk.

Summary of the Characteristics of the Indirect and Direct Teachers

The results of the Darwin chi-square indicated that the matrices for the indirect and the direct teachers were different. But how did these two imaginary teachers differ?

The difference between the indirect and direct teacher may now be summarized. The indirect teacher, compared with the direct teacher: (a) talked less (Table X); (b) used, developed, and encouraged the pupils' ideas more often; (c) asked more questions; (d) lectured less often and for shorter periods of time; (e) criticized pupils less often; (f) had less class time spent in silence or confusion; (g) had pupils who responded more to questions and who exhibited more lengthy periods of sustained, pupil-initiated responses to the lesson.

Summary of the Characteristics of the Teacher-Pupil Sample

Table X summarizes the sample of pupils and teachers as reported and developed within this chapter.

Included in Table X are: (a) grouping of teachers and pupils according to indirect, average, and direct groups; (b) numbers of pupils

TABLE X

COMPARISON OF INDIRECT, AVERAGE, AND DIRECT TEACHER - PUPIL GROUPS

Group	No. of Pupils	Science Mean	Science S.D.	IQ Mean	IQ S.D.	I/D for Composite Matrix	Teacher Talk, %*	Pupil Talk, %*	Silence, %*
Indirect Teachers									
101	38	46.03	4.56	115.90	12.46	1.009	64.30	32.10	3.60
104	28	43.79	5.00	114.86	13.02	1.855	60.44	27.88	11.68
107	30	47.03	4.90	115.53	12.43	1.194	55.93	38.22	5.85
Total Group	96	45.69	4.97	115.48	12.63	1.295	60.25**	32.72**	7.03**
Average Teachers									
102	34	44.62	5.53	114.18	13.11	0.569	63.76	23.39	12.85
103	29	41.28	7.23	105.93	16.46	0.996	66.13	25.94	7.93
106	34	43.50	5.61	116.18	12.37	0.628	63.72	29.18	7.10
Total Group	97	43.23	6.26	112.41	14.61	0.713	64.55**	26.15**	9.30**
Direct Teachers									
105	28	38.21	7.98	109.21	14.56	0.429	55.83	21.31	22.86
108	38	41.45	6.15	106.42	12.33	0.443	77.23	13.55	9.22
Total Group	66	40.08	7.17	107.61	13.40	0.437	66.55**	17.40**	16.05**

* See Appendix H for details

** See Tables VI, VII, VIII for details

within each group; (c) pupil science and IQ mean scores according to class and according to group; (d) pupil science and IQ standard deviations; (e) indirect to direct ratios for each of the eight teachers' composite matrices; (f) percentage of teacher talk, pupil talk, and silence as represented in the composite matrices (Appendix H); (g) percentage of teacher talk, pupil talk, and silence as represented in the combined matrices (Tables VI, VII, VIII).

THE NULL HYPOTHESES AND ANALYSES USED

The problem studied may be expressed in interrogative terms: Is there a significant relationship between grade six pupil achievement in the inquiry skills in science and teacher-pupil verbal interaction patterns?

The following null hypotheses were tested:

Hypothesis 1: There is no significant difference in the interaction matrices of teachers classified as indirect versus teachers classified as direct.

Hypothesis 2: Teacher experience and science background are not significantly related to pupil achievement in inquiry in science.

Hypothesis 3: There is no significant interaction among pupil intelligence, teacher-pupil verbal interaction patterns, and pupil achievement in inquiry in science.

Hypothesis 4: There is no significant relationship between teacher-pupil verbal interaction patterns and pupil achievement in inquiry in science.

Hypothesis 5: There is no significant interaction among pupil sex, teacher-pupil verbal interaction patterns, and pupil achievement in inquiry in science.

Hypothesis 6: There is no significant difference in teacher flexibility between indirect and direct teachers.

The order and characteristics of the hypotheses are best explained in terms of the analyses employed. Briefly, the analyses used multiple regression equations. The method is reflected in Flathman's (1968) paper, prepared and published at the University of Alberta, Edmonton. The MULRO4 computer program was used for the regression equations. The DEST02 was used to calculate mean science achievement, mean IQ, and SD scores.

Six hypotheses were tested. The summary, below, attempts to explain the logical sequence and analyses used:

Hypothesis 1

As a first step, it was necessary to establish whether or not the indirect imaginary teacher was significantly different from the imaginary direct teacher. Darwin's chi-square test was used to test for the significance of differences between the indirect teacher's composite matrix and the direct teacher's composite matrix.

Hypothesis 2

Second, it was necessary to study the relationships between teacher experience and science background, and pupil achievement in inquiry in science. If significant relationships existed, then these two teacher factors would have to be included in the regression equations in the study of subsequent hypotheses. Hypothesis 2, then, studied the

relationship between teacher experience and science background, and pupil achievement in inquiry in science. Pearson Product Moment correlations were used to test these relationships.

Hypotheses 3 and 4

The third stage of the analyses examined the relationship among pupil IQ, teacher-pupil verbal interaction patterns, and pupil achievement in inquiry in science. (These may be considered the main hypotheses of the study.) Multiple regression analyses, using the MULRO4 computer program supplied by the Division of Educational Research Services, University of Alberta, were used. Five steps were involved:

- Step 1: Tested for linearity of fit between the criterion score (pupil achievement) and pupil IQ.
- Step 2: After establishing linearity of fit, proceeded with an analysis of covariance.
- Step 3: Tested for interaction between pupil IQ and teacher-pupil verbal interaction patterns (Hypothesis 3).
- Step 4: Established the fact that there was no such interaction.
- Step 5: Tested the hypothesis that there is no significant relationship between teacher-pupil verbal interaction patterns and pupil achievement in inquiry in science (Hypothesis 4), controlling for pupil IQ.

Hypothesis 5

A similar analysis was used to test this hypothesis. Regression analyses, using the MULRO4 computer program, were used to test for the significance of interaction between pupil sex, teacher verbal interaction patterns, and pupil achievement in inquiry in science.

Hypothesis 6

The relationship between teacher influence patterns and teacher flexibility was presented in descriptive form.

CHAPTER IV

THE RESULTS OF THE ANALYSES

OVERVIEW

The main hypotheses of this study were supported by evidence that pupil achievement in inquiry in science were significantly higher for those classes in which the teachers were more indirect. Teacher flexibility of influence was found to be significantly related to indirectness of verbal interaction patterns.

In addition, the results of the analyses showed that teacher verbal influence patterns affected boys and girls of all intelligence levels more or less equally. That is to say, there was no interaction either between pupil intelligence or pupil sex and teacher verbal interaction patterns.

The overall results for the six hypotheses are summarized in the final section of this chapter.

THE VARIABLES DEFINED

Eleven variables were used in the analyses which follow. A description of each of the variables appears below:

X_1 = pupil intelligence quotient

X_2 = pupil achievement in inquiry in science

X_3 = teacher science courses (number)

X_4 = teacher experience (years)

X_5 = pupil sex (1 for male; 0 otherwise)

X_6 = indirect teachers

X_7 = average teachers

X_8 = direct teachers

$X_9 = X_1 * X_6$ = interaction between pupil IQ and indirect group

$X_{10} = X_1 * X_7$ = interaction between pupil IQ and average group

$X_{11} = X_1 * X_8$ = interaction between pupil IQ and direct group

$X_{12} = X_5 * X_6$ = interaction between pupil sex and indirect group

$X_{13} = X_5 * X_7$ = interaction between pupil sex and average group

$X_{14} = X_5 * X_8$ = interaction between pupil sex and direct group

TEACHER CHARACTERISTICS AND PUPIL SCIENCE ACHIEVEMENT

Hypothesis 1

Three imaginary teachers were created from the eight teachers who were involved in this study. One imaginary teacher, described as indirect, was created from the composite matrices of teachers 101, 104, and 107. The second imaginary teacher, described as average, was created from the composite matrices of teachers 102, 103, and 106. The third imaginary teacher, described as direct, was created from the composite matrices of teachers 105 and 108. (See Tables VI, VII, VIII for the matrices of the three imaginary teachers.)

A Darwin chi-square test was used to test to see if the combined matrix for the indirect teachers was significantly different from that of the direct teachers. The test results indicated a Darwin chi-square of 16.1338. This score was converted to a standard score, Z. (For two 10 x 10 matrices when Z is 2.58 or larger, the null hypothesis is rejected at the 0.01 level of confidence.) The Z score in this study was calculated to be 9.432, indicating a difference between the two matrices

well beyond the 0.01 level of confidence. (A complete description of the procedure for testing the significance of the difference between two matrices by Darwin's method appears in Appendix F. An APL360/67 program, developed by the writer for the speedy calculation of Darwin's chi-square and Z scores, is presented in Appendix G.)

The Darwin chi-square test showed that the matrix for the imaginary indirect teacher was significantly different from that of the imaginary direct teacher. In other words, the null Hypothesis 1 was rejected.

Hypothesis 2

As a part of the MULRO4 computer program, Pearson Product Moment correlations are computed between all variables.

Table XI summarizes the correlations between science achievement (X_2) and (a) pupil IQ (X_1); (b) pupil sex (X_5); (c) teacher science background (X_3); and (d) teacher experience (X_4).

The correlation between science achievement (X_2) and teacher science background (X_3) was calculated to be -0.0603. Tables of statistics show that for six degrees of freedom (eight teachers minus two degrees of loss of information) the correlation coefficient would have to be 0.834 or higher to be significant at the 0.01 level of confidence. For the purpose of this study, then, teacher science background was not significantly related to science achievement.

The correlation between science achievement (X_2) and teacher experience (X_4) was calculated to be 0.2269. With six degrees of freedom the correlation coefficient would have had to be 0.834 or higher to be significant at the 0.01 level of confidence. For the purpose of this study, then, teacher experience was not significantly related to science achievement.

TABLE XI
PEARSON PRODUCT MOMENT CORRELATIONS BETWEEN
INQUIRY ACHIEVEMENT AND (a) PUPIL IQ,
(b) PUPIL SEX, (c) TEACHER SCIENCE BACKGROUND,
(d) TEACHER EXPERIENCE

	Pupil IQ	Pupil Sex	Teacher Science Background	Teacher Experience
Science Achievement	0.6622*	0.0419	-0.0603	0.2269

* Significant beyond the 0.01 level

With this small sample of eight teachers the fact that teacher science background and experience were not highly correlated with pupil achievement in inquiry in science is not considered unusual. Perhaps with a teacher sample of one hundred, or more, teacher science background and experience might well be significant predictors of pupil achievement in inquiry in science.

However, for the purpose of this study, the teacher characteristics of science background and experience were identified merely to control for these factors in the regression equations.

INTERACTION AMONG PUPIL INTELLIGENCE TEACHER VERBAL PATTERNS, AND PUPIL INQUIRY ACHIEVEMENT

Hypothesis 3

The Pearson Product Moment correlation between pupil science achievement (X_2) and pupil IQ (X_1) was found to be 0.6622 (Table X). This correlation indicated a very high relationship, i.e., significant beyond the 0.01 level of confidence.

The next question asked was whether or not any interaction existed between pupil IQ (X_1), teacher verbal interaction patterns (X_6, X_7, X_8), and pupil science achievement in inquiry (X_2).

Even though a high correlation existed, it was necessary to test to see if there was linearity of fit, i.e., that a plot of pupil IQ (X_1) versus pupil achievement (X_2) formed an approximate line rather than a curve. Figure 5 represents a plot of X_1 versus X_2 for the pupil scores of the indirect teachers. The assumption that a straight line fit the data (rather than a curve) appeared reasonable. The graphs for average and direct teachers were similar to the graph illustrated in Figure 5.

Hypothesis 3 involved the interaction between pupil IQ (X_1), teacher verbal interaction patterns (X_6, X_7, X_8), and pupil achievement in inquiry in science (X_2).

The analysis is described below by the use of two regression equations and Figures 6 and 7.

Model 1 (full model):

$$X_2 = a_6X_6 + a_7X_7 + a_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + e_1$$

where a_6, a_7, a_8 are the y-intercepts of the three lines represented in the full model as illustrated in Figure 6, and where b_9, b_{10}, b_{11} are the slopes of the same three lines.

The computer output estimates were:

$$\begin{array}{ll} a_6 = 17.413 & b_9 = 0.245 \\ a_7 = 9.511 & b_{10} = 0.300 \\ a_8 = 4.867 & b_{11} = 0.327 \end{array}$$

From these values for the slopes and y-intercepts of the three lines, the science achievement score for any pupil in the three groups

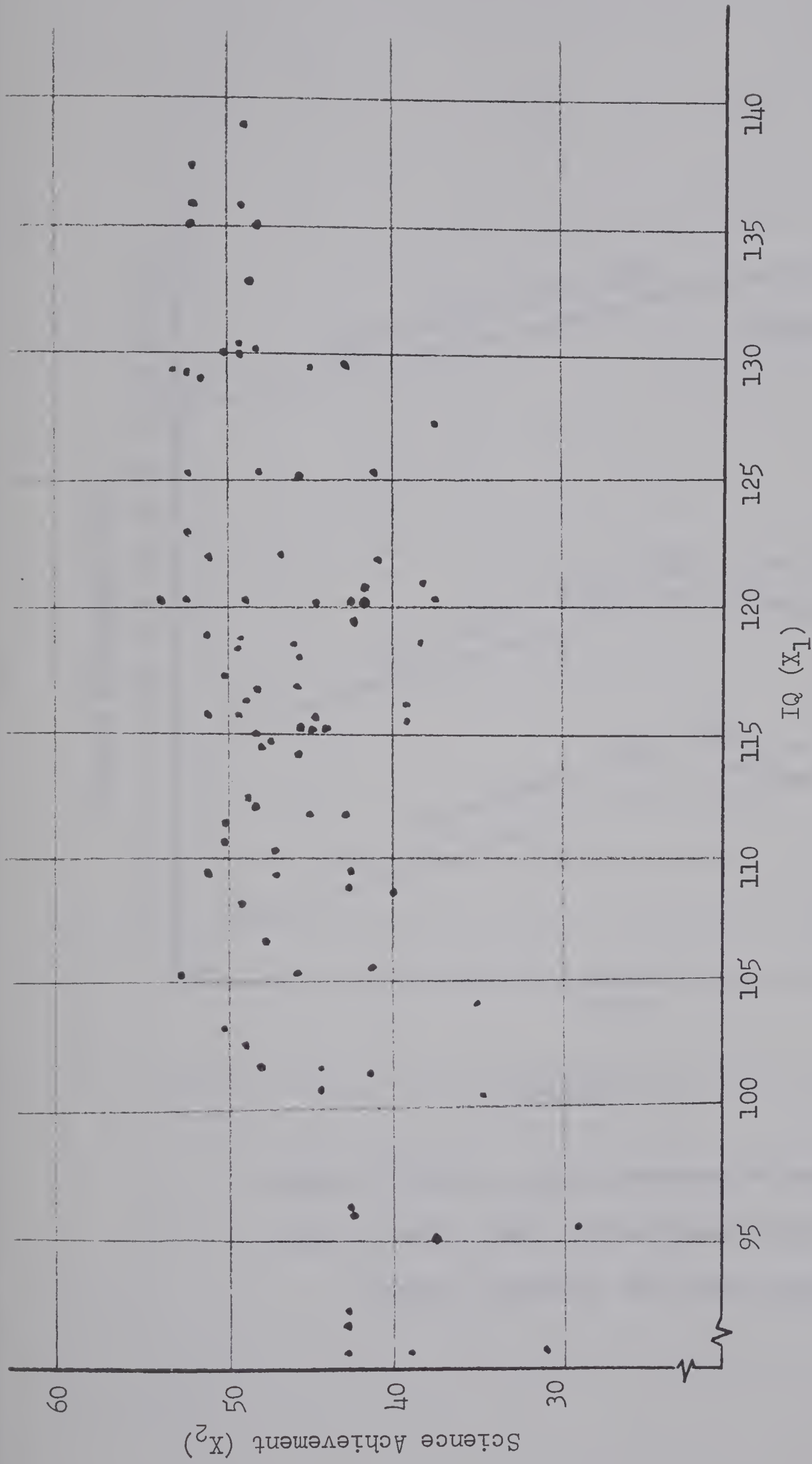


FIGURE 5

Graph of Pupil Science Achievement in Inquiry Versus
Pupil Intelligence Quotient for Indirect Teachers

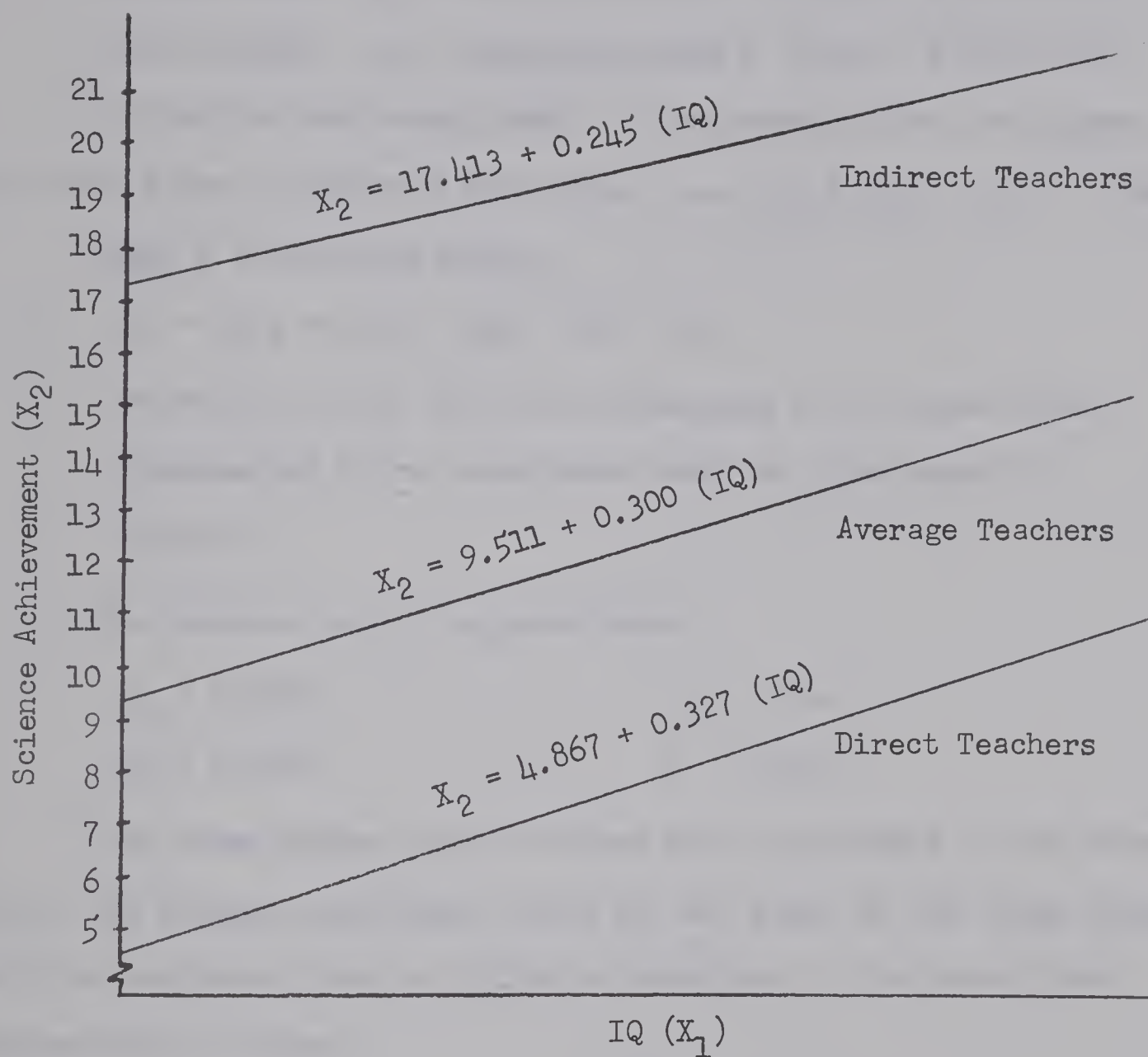


FIGURE 6

Graph of Model 1: Pupil Science Achievement in
Inquiry Versus Pupil Intelligence Quotient for
Indirect, Average, and Direct Teachers

could be predicted from the following equations of the three lines represented in Figure 6:

$$\text{Indirect Group; } X_2 = \text{predicted score} = 17.413 + 0.245 (\text{IQ})$$

$$\text{Average Group; } X_2 = \text{predicted score} = 9.511 + 0.300 (\text{IQ})$$

$$\text{Direct Group; } X_2 = \text{predicted score} = 4.867 + 0.327 (\text{IQ})$$

To form the restricted model, it was assumed that the slopes of the three lines in Figure 6 were equal, i.e., $b_9 = b_{10} = b_{11} = b$ (say).

Model 2 (restricted model):

$$X_2 = a_6 X_6 + a_7 X_7 + a_8 X_8 + b X_1 + e_1$$

where a_6 , a_7 , a_8 are the y-intercepts of the three lines represented in the restricted model as illustrated in Figure 6.

The computer output estimates were:

$$a_6 = 12.585$$

$$a_8 = 9.240$$

$$a_7 = 11.024$$

$$b = 0.286$$

From these values for the slopes and y-intercepts of the three lines, the science achievement score for any pupil in the three groups could be predicted from the following equations of the three lines represented in Figure 7:

$$\text{Indirect Group; } X_2 = 12.585 + 0.286 (\text{IQ})$$

$$\text{Average Group; } X_2 = 11.024 + 0.286 (\text{IQ})$$

$$\text{Direct Group; } X_2 = 9.240 + 0.286 (\text{IQ})$$

The regression analysis, comparing the full model with the restricted model, gave an F ratio of 2.2973. With 2 degrees of freedom (d.f.) in the numerator and 253 d.f. in the denominator, the probability was calculated to be 0.1026.

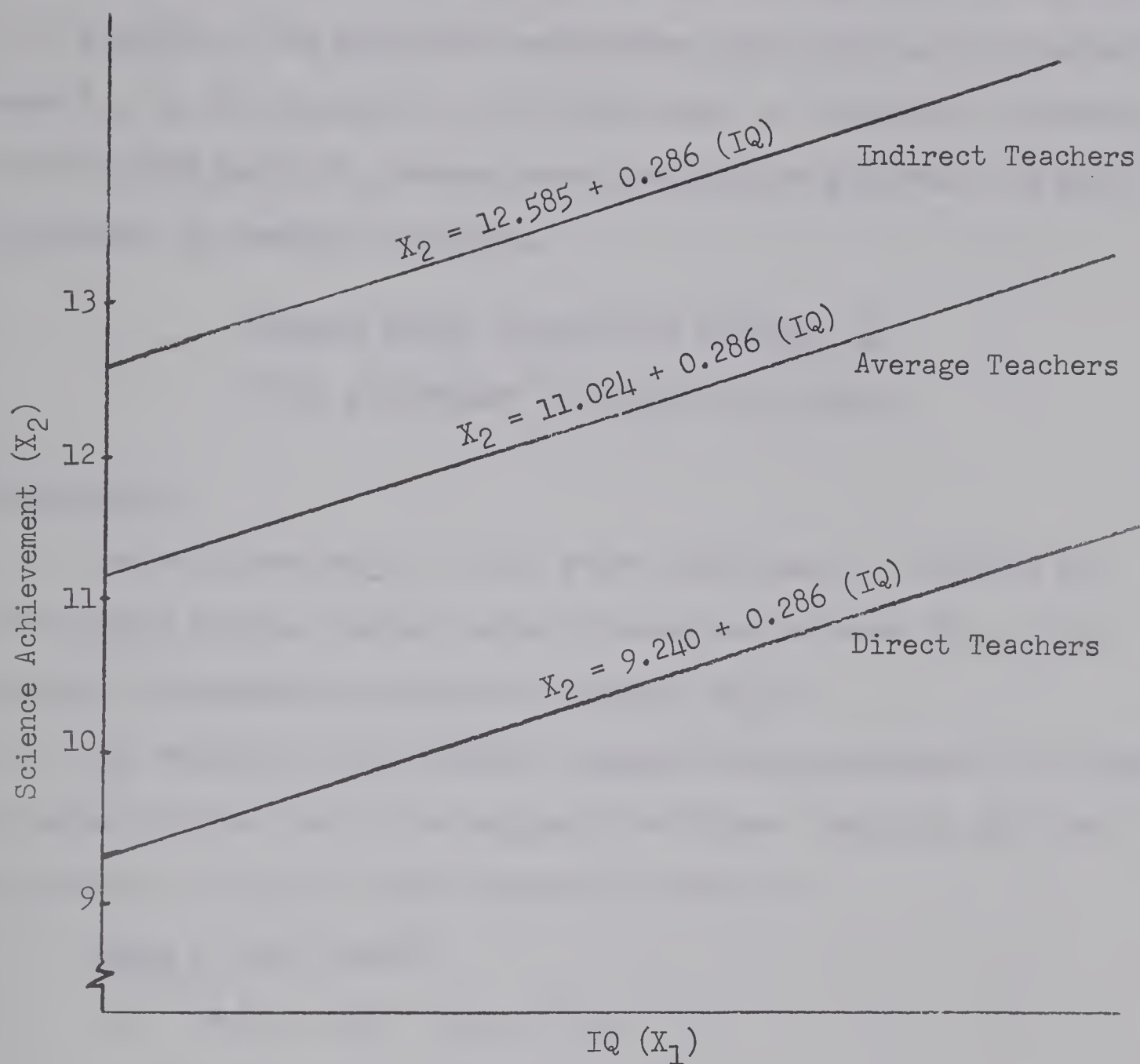


FIGURE 7

Graph of Model 2: Pupil Science Achievement in
Inquiry Versus Pupil Intelligence Quotient for
Indirect, Average, and Direct Teachers

Since a probability of 0.1026 was considered large, the restricted model was accepted. The three regression lines (Figure 7) were assumed to be parallel. The conclusion was reached that there was no interaction among X_1 , X_6 , X_7 , X_8 , and X_2 . In other words, no significant interaction existed among pupil IQ, teacher verbal interaction patterns, and pupil achievement in inquiry in science.

TEACHER VERBAL INTERACTION PATTERNS AND PUPIL ACHIEVEMENT IN INQUIRY IN SCIENCE

Hypothesis 4

The main hypothesis in this study, Hypothesis 4, involved the relationship between teacher verbal interaction patterns (X_6 , X_7 , X_8) and pupil achievement in inquiry in science (X_2).

The results of the analysis completed under Hypothesis 3 provided the model for the form of the analysis to follow. Pupil IQ (X_1) had to be included in the full model regression equation.

Model 3 (full model):

$$X_2 = a_6X_6 + a_7X_7 + a_8X_8 + bX_1 + e_1$$

$$\text{where } a_6 = 12.585$$

$$a_8 = 9.240$$

$$a_7 = 11.024$$

$$b = 0.286$$

(This model was illustrated under the analysis of Hypothesis 3 and the three lines appear in Figure 7.)

To form the restricted model, it was assumed that the three lines, as represented in Figure 7, could be considered one line without a significant loss of information. In other words, $a_6 = a_7 = a_8 = a$ (say) and $X_6 + X_7 + X_8 = u$ (all pupils in the sample).

Model 4 (restricted model):

$$X_2 = a + bX_1 + e_2$$

where a = y-intercept = 8.863

b = slope = 0.307

From these values of a and b , the science achievement score for any pupil in the total sample could be predicted from the equation, $X_2 = 8.863 + 0.307 (IQ)$, as illustrated in Figure 8.

The regression analysis, comparing the full model with the restricted model, gave an F ratio of 9.5471. With 2 d.f. in the numerator and 255 d.f. in the denominator, the probability was calculated to be 0.0001.

Since a probability of 0.0001 was considered very small, the restricted model was rejected. Too much information was lost in collapsing the three lines (Figure 7) onto one line (Figure 8).

Allowing for differences in IQ between groups, there was a significant difference between mean science achievement scores for the two groups. The conclusion was reached that there was a very significant relationship between teacher verbal interaction patterns and pupil achievement in inquiry in science.

INTERACTION AMONG PUPIL SEX, TEACHER VERBAL PATTERNS, AND PUPIL ACHIEVEMENT IN INQUIRY IN SCIENCE

Hypothesis 5

The Pearson Product Moment correlation between pupil science achievement (X_2) and pupil sex (X_5) was found to be 0.0419 (Table X). To be statistically significant at the 0.01 level this correlation would have had to be greater than 0.170.

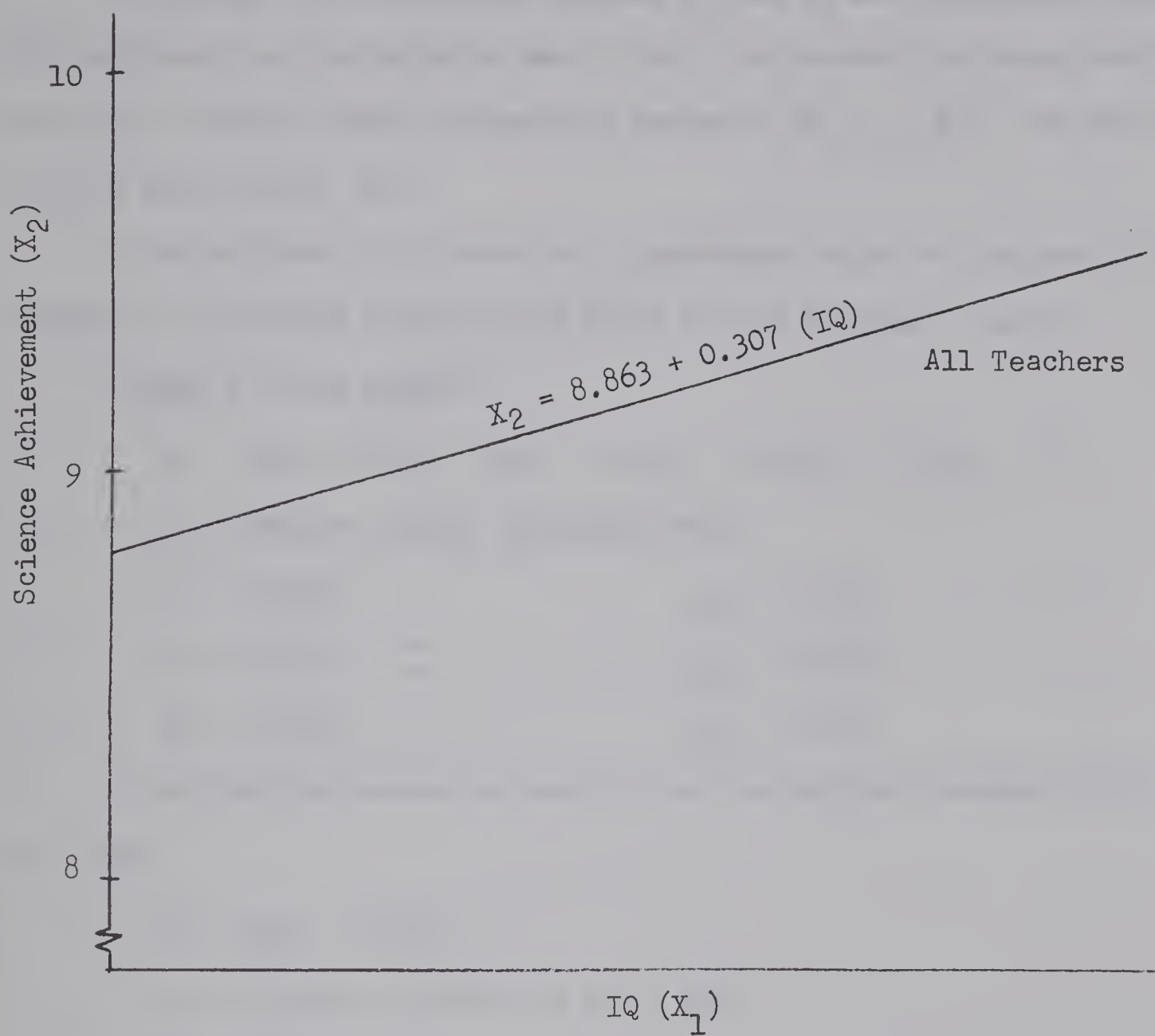


FIGURE 8

Graph of Model 4: Pupil Science Achievement in
Inquiry Versus Pupil Intelligence Quotient

Although the correlation between X_2 and X_5 was considered low, the next step in the analysis was to test for interaction among pupil sex (X_5), teacher verbal interaction patterns (X_6, X_7, X_8), and pupil science achievement (X_2).

The analysis of interaction is described below by the use of two regression equations (Model 5 and Model 6) and Figures 9 and 10.

Model 5 (full model):

$$X_2 = a_6X_6 + a_7X_7 + a_8X_8 + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + e_1$$

The computer output estimates were:

$$a_6 = 45.405 \qquad b_{12} = 0.554$$

$$a_7 = 43.123 \qquad b_{13} = 0.180$$

$$a_8 = 40.083 \qquad b_{14} = 0.000$$

The predicted score for any boy in the indirect teacher group (X_6) was:

$$X_2 = a_6X_6 + b_{12}X_{12}$$

$$X_2 = 45.405 + 0.554 (1.0 \text{ for a boy})$$

$$X_2 = 45.959$$

The predicted score for any girl in the indirect teacher group (X_6) was:

$$X_2 = a_6X_6 + b_{12}X_{12}$$

$$X_2 = 45.405 + 0.554 (0.0 \text{ for a girl})$$

$$X_2 = 45.405$$

The predicted score for any boy in the average teacher group (X_7) was:

$$X_2 = a_7X_7 + b_{13}X_{13}$$

$$X_2 = 43.123 + 0.180 (1.0 \text{ for a boy})$$

$$X_2 = 43.303$$

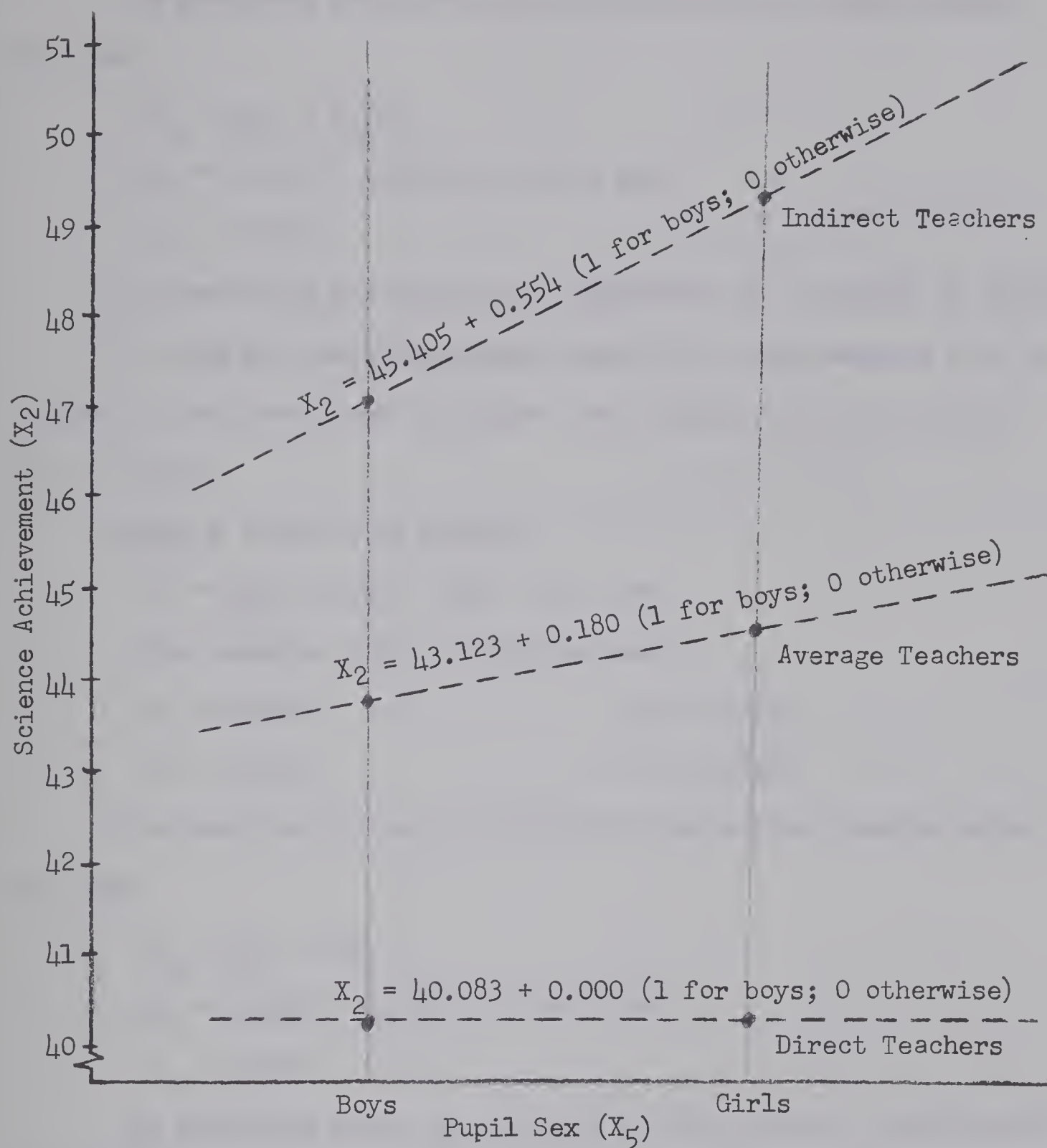


FIGURE 9

Graph of Model 5: Pupil Science Achievement in
Inquiry Versus Pupil Sex for Indirect,
Average, and Direct Teachers

The predicted score for any boy in the direct teacher group (X_8) was:

$$X_2 = a_8 X_8 + b_{14} X_{14}$$

$$X_2 = 40.083 + 0.000 \text{ (1.0 for a boy)}$$

$$X_2 = 40.083$$

The resulting six points are represented in the graph in Figure 9.

To form the restricted model (Model 6), it was assumed that the slopes of the three lines in Figure 9 were equal, i.e., $b_{12} = b_{13} = b_{14} = b$ (say).

Model 6 (restricted model):

$$X_2 = a_6 X_6 + a_7 X_7 + a_8 X_8 + b X_5 + e_1$$

The computer output estimates were:

$$a_6 = 45.545$$

$$a_8 = 39.955$$

$$a_7 = 43.094$$

$$b = 0.268$$

The predicted score for any boy in the indirect teacher group (X_6) was:

$$X_2 = a_6 X_6 + b X_5$$

$$X_2 = 45.545 + 0.268 \text{ (1.0 for a boy)}$$

$$X_2 = 45.813$$

The predicted score for any girl in the indirect teacher group

(X_6) was:

$$X_2 = a_6 X_6 + b X_5$$

$$X_2 = 45.545 + 0.268 \text{ (0.0 for a girl)}$$

$$X_2 = 45.545$$

The resulting six points are represented in the graph in Figure 10.

The regression analysis, comparing the full model (Model 4) with the restricted model (Model 5), gave an F ratio of 0.0443. With 2 d.f.

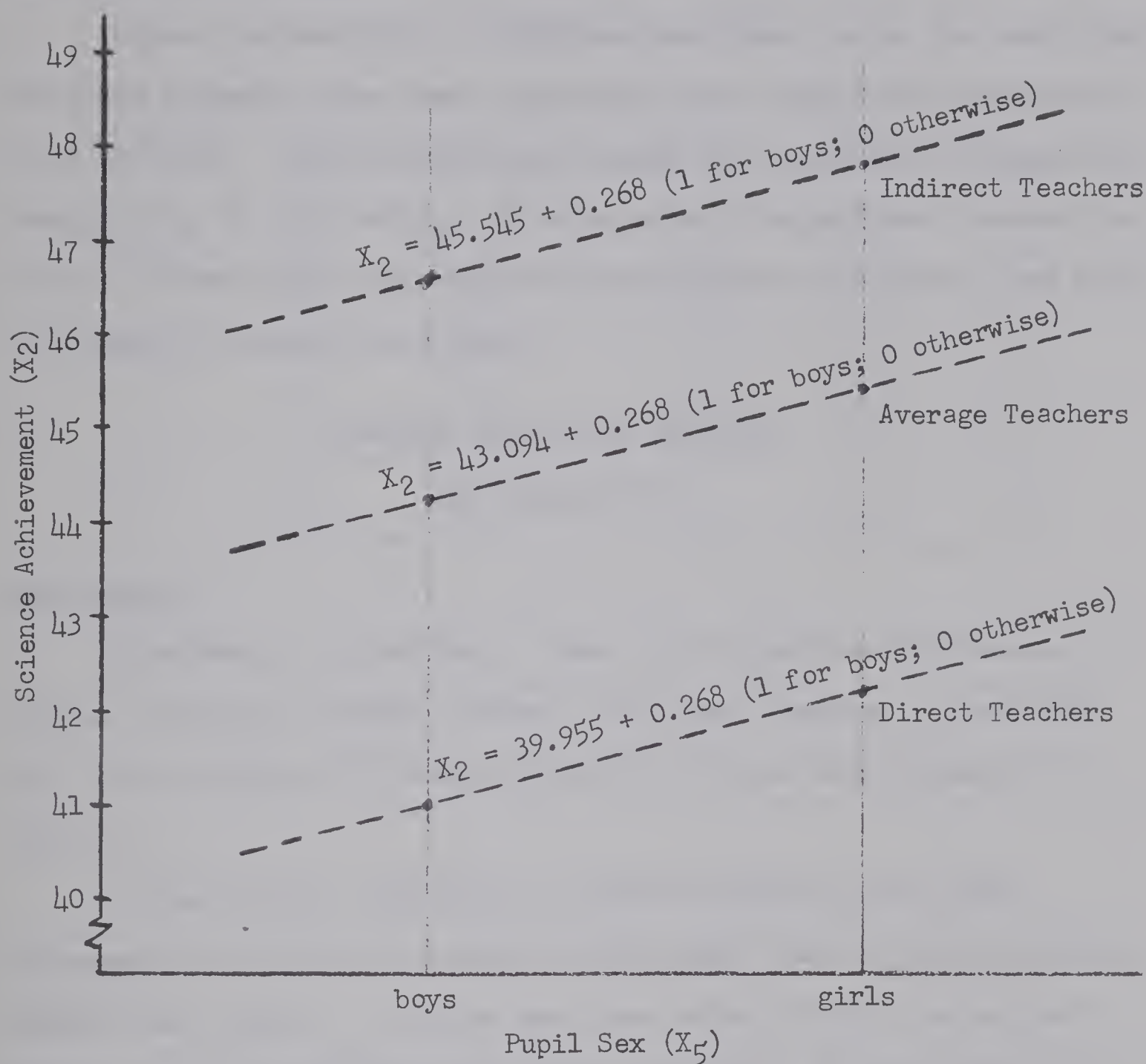


FIGURE 10

Graph of Model 6: Pupil Science Achievement in
Inquiry Versus Pupil Sex for Indirect,
Average, and Direct Teachers

in the numerator and 253 d.f. in the denominator, the probability was calculated to be 0.9568.

Since a probability of 0.9568 was considered large, the restricted model was accepted. The three regression lines (Figure 10) were assumed to be parallel. The conclusion was reached that there was no interaction among X_5 , X_6 , X_7 , X_8 , and X_2 . In other words, insignificant interaction existed between pupil sex, teacher verbal interaction patterns, and pupil achievement in inquiry in science.

TEACHER INTERACTION PATTERNS

AND FLEXIBILITY

Hypothesis 6

Hypothesis 6 stated that: There is no significant difference in teacher flexibility between indirect and direct teachers. (The definition and calculation of teacher flexibility scores were presented in Table IV.)

Table XII is a comparison of teacher flexibility and pupil achievement in inquiry in science for the three teacher groups; indirect, average, and direct. It can be seen from Table XII that the indirect teachers were more flexible than direct teachers. In other words, the indirect teachers varied their approach to a greater extent according to the nature of the teaching task at hand.

Teacher 107 (flexibility = 0.715; pupil mean science achievement = 47.03; pupil mean IQ = 115.53) was compared with teacher 105 (flexibility = -0.322; pupil mean science achievement = 38.21; pupil mean IQ = 109.21). How did these two teachers differ in terms of flexibility? Teacher 107 used a more indirect verbal approach when introducing new material, when

TABLE XII
A COMPARISON OF TEACHER FLEXIBILITY WITH
PUPIL ACHIEVEMENT IN SCIENCE

Assignment	Teacher Code Number	I/D for Composite Matrix	Teacher Flexibility	Mean IQ	Mean Science
INDIRECT	101	1.009	0.912	115.90	46.03
	104	1.855	0.163	114.86	43.79
	107	1.194	0.715	115.53	47.03
AVERAGE	102	0.569	0.202	114.18	44.62
	103	0.996	0.183	105.93	41.28
	106	0.628	0.458	116.18	43.50
DIRECT	105	0.429	(-0.322)	109.21	38.21
	108	0.443	0.259	106.42	41.45

demonstrating a science experiment, or when students were experimenting. However, when reviewing previously learned material, evaluating pupil progress, or when conducting routine classroom administration, teacher 107 was more direct. Teacher 105, on the other hand, not only varied his verbal behavior patterns less but was more direct when introducing new subject material and more indirect when reviewing previously learned material.

Indirect teacher 104 appeared not to follow the same pattern as the other teachers in that his flexibility score of 0.163 was lower than 0.259 for direct teacher 108. The apparent contradiction is soon dispelled by referring to Table IV. Although teacher 104 had a relatively low flexibility ratio, his I/D ratios were 1.709 for classroom categories i) and iii) and 1.872 for categories ii) and iv). The flexibility score for teacher 108, although larger than that of teacher 104, was based on I/D ratios for categories i) and iii) of 0.289 and 0.548 for categories ii) and iv).

The conclusion was reached that indirect teachers tended to be more flexible in their verbal influence patterns than did the direct teachers. That is to say, the indirect teachers tended to use a more indirect approach when introducing new science material or when science demonstration and experimentation was in progress. However, the indirect teachers tended to be more direct in their verbal interaction with pupils when performing routine administrative matters or when reviewing previously-learned science material. In addition, predicting pupil achievement in inquiry in science may, perhaps, be more accurate if teacher I/D ratios are interpreted in conjunction with teacher flexibility scores.

TEACHER VERBAL INTERACTION PATTERNS AND PUPIL ACHIEVEMENT IN INQUIRY IN SCIENCE, CONTROLLING FOR TEACHER AND PUPIL CHARACTERISTICS

The foregoing analysis dealt with pupil IQ (X_1), pupil sex (X_5), teacher science background (X_3), and teacher experience (X_4). As far as pupil IQ and sex were concerned, it was established that: (a) the correlations between these two variables and pupil achievement (X_2) was insignificant, (b) there was no interaction among these two variables, teacher verbal patterns (X_6, X_7, X_8) and pupil achievement in inquiry in science (X_2). As far as teacher characteristics were concerned, it was established that neither teacher science background or teacher experience was significantly correlated with pupil achievement (X_2).

The question arose: What effect would the inclusion of the pupil characteristics (X_1, X_5) and teacher characteristics (X_3, X_4) have on the regression equations as studied under Hypothesis 4?

So that the analyses could be considered complete, four additional regression equations were created and compared (Model 7, Model 8, Model 9,

Model 10).

Model 7 (full model):

$$X_2 = a_1X_1 + a_3X_3 + a_4X_4 + a_6X_6 + a_7X_7 + a_8X_8 + e_1$$

In this model, pupil sex (X_1), teacher science background (X_3), and teacher experience (X_4) were controlled for in the regression equations. The computer output estimates were:

$$\begin{array}{ll} a_1 = 11.273 & a_5 = 11.692 \\ a_3 = 10.824 & a_6 = 10.706 \\ a_4 = 11.049 & a_7 = 8.831 \end{array}$$

The creation of the restricted model (Model 8) assumed that group membership did not affect pupil achievement. In other words, not much information would be lost in assuming that all pupils in the sample had essentially the same type of teacher.

Model 8 (restricted model):

$$X_2 = a_1X_1 + a_3X_3 + a_4X_4 + a + e_2$$

The computer output estimates were:

$$\begin{array}{ll} a_1 = 8.441 & a_4 = 8.248 \\ a_2 = 8.076 & a = 8.137 \end{array}$$

The regression analysis, comparing the full model (Model 7) with the restricted model (Model 8), gave an F ratio of 4.3573. With 3 d.f. in the numerator and 253 d.f. in the denominator, the probability was calculated to be 0.0052.

Since a probability of 0.0052 was considered small, the restricted model (Model 8) was rejected. The conclusion was reached that: controlling for pupil IQ, teacher science background, and teacher experience, the indirect teachers' pupils achieved significantly higher in inquiry in science than did the direct teachers' pupils.

One variable remained, pupil sex. The models presented below (Model 9, Model 10) both contain pupil IQ (X_1), pupil sex (X_5), teacher science background (X_3), and teacher experience (X_4).

Model 9 (full model):

$$X_2 = a_1X_1 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8 + e_1$$

The computer output estimates were:

$$a_1 = 10.518$$

$$a_6 = 10.642$$

$$a_3 = 10.080$$

$$a_7 = 9.686$$

$$a_4 = 10.291$$

$$a_8 = 7.879$$

$$a_5 = 11.287$$

The creation of the restricted model (Model 10) assumed that group membership did not affect pupil achievement.

Model 10 (restricted model):

$$X_2 = a_1X_1 + a_3X_3 + a_4X_4 + a_5X_5 + a_u + e_2$$

The computer output estimates were:

$$a_1 = 7.360$$

$$a_5 = 8.315$$

$$a_3 = 7.000$$

$$a_u = 7.052$$

$$a_4 = 7.163$$

The regression analysis, comparing the full model (Model 9) with the restricted model (Model 10), gave an F ratio of 5.9312. With 3 d.f. in the numerator and 252 d.f. in the denominator, the probability was calculated to be 0.0030.

Since a probability of 0.0030 was considered very small, the restricted model (Model 10) was rejected. The conclusion was reached that: controlling for pupil IQ and sex, and teacher science background and experience, the indirect teachers' pupils achieved significantly higher in inquiry in science than did the direct teachers' pupils.

The information gained from the analysis of the four models, just presented, provided additional support for the main hypothesis of this study, Hypothesis 4.

SUMMARY OF THE RESULTS

The principal findings in relation to the hypotheses tested are briefly summarized:

Hypothesis 1

There is no significant difference in the interaction matrices of teachers classified as indirect versus teachers classified as direct.

This hypothesis was rejected. The indirect teacher (created from the matrices of the three indirect teachers) was significantly different from the direct teacher (created from the matrices of the two direct teachers).

Hypothesis 2

Teacher experience and science background are not significantly related to pupil achievement in inquiry in science.

This hypothesis was accepted. The correlations between pupil achievement and teacher characteristics were not significant.

Hypothesis 3

There is no significant interaction among pupil intelligence, teacher-pupil verbal interaction patterns, and pupil achievement in inquiry in science.

This hypothesis was accepted. Pupils of all intelligence levels were affected more or less equally by the indirect, average, or direct verbal interaction influence.

Hypothesis 4

There is no significant relationship between teacher-pupil verbal interaction patterns and pupil achievement in inquiry in science.

This hypothesis was rejected. The pupils whose teachers were classified as indirect achieved significantly higher in inquiry in science than did the pupils whose teachers were classified as direct.

Hypothesis 5

There is no significant interaction among pupil sex, teacher-pupil verbal interaction patterns, and pupil achievement in inquiry in science.

This hypothesis was accepted. The achievement in inquiry in science among boys was approximately equal to the achievement of girls within the indirect classrooms. This same relationship was found for the average classrooms and the direct classrooms. In other words, teacher verbal interaction patterns affected equally the achievement of boys and girls.

Hypothesis 6

There is no significant difference in teacher flexibility between indirect and direct teachers.

This hypothesis was rejected. Indirect teachers, generally, were found to vary their verbal interaction patterns more according to the nature of the classroom activity.

CHAPTER V

DISCUSSION AND IMPLICATIONS

DISCUSSION OF FINDINGS

The two major hypotheses were supported by an analysis of data from interaction analysis and achievement in inquiry in sixth grade science. The results of this study suggest that a teacher who exhibits indirect verbal interaction patterns will have pupils who achieve higher in inquiry skills in science. A teacher who is able to provide flexible patterns of influence, by shifting from indirect to direct interaction in terms of the characteristics of the classroom activity, creates an environment or climate in which pupils tend to learn more. The pupils of a more direct and inflexible teacher tend to learn less.

What factors differentiate the indirect teacher from the direct teacher; the flexible teacher from the inflexible teacher? (Tables VI, VII, VIII, IX, and XII and Figure 2 offer some evidence for a comparison of these two groups of teachers; the indirect versus the direct and the flexible versus the inflexible.) The indirect teacher: (a) talks less, (b) uses, develops, and encourages the pupils' ideas more often, (c) asks more questions, (d) lectures less often and for shorter periods of time, (e) criticizes pupils less often, (f) has pupils who respond more to questions and who exhibit more lengthy periods of sustained, pupil-initiated responses to the lesson. The flexible teacher, in comparison with the inflexible teacher: (a) is generally more indirect than direct in his classroom verbal interaction

patterns and (b) exhibits a wider range of verbal interaction patterns as the classroom activities vary. (Table IV, XII, and the definition of teacher flexibility on page 34 offer evidence to support these two conclusions.) For example, when the classroom activities involve the introduction of new science content, demonstration of experiments, and individual pupil experimentation, the flexible teacher tends to be more indirect. But as the pupils' learning goals become more clear, the flexible teacher tends toward a more direct approach. In other words, during classroom activities such as reviewing previously taught ideas, principles, and concepts, the flexible teacher tends to be more direct. The inflexible teacher, on the other hand, tends toward a fairly consistent pattern of verbal interaction regardless of the nature of the lesson.

The major findings of this study, namely, that there is a significant relationship between teacher verbal interaction patterns and pupil achievement in inquiry in science, are consistent with those of Flanders (1965) in his Minnesota Study. Flanders concluded, from his two year study, that:

(1) Indirect teacher influence increases learning when a student's perception of the goal is confused and ambiguous.

(2) Direct teacher influence increases learning when a student's perception of the goal is clear and acceptable [p. 108].

Another significant finding involves the interaction among pupil intelligence and sex, teacher verbal interaction patterns, and pupil achievement in inquiry in science. It may be concluded, that within the target population, already defined, the indirect and flexible teacher affects the achievement of boys and girls of all intelligence levels more or less equally.

These conclusions must be interpreted in terms of the target population defined in Chapter III; a target population involving those fifty-six grade six teacher-class units presently on the new elementary science program within the Edmonton Separate School District, Number 7.

Another word of caution should be added. Ryan's (1964) concluding remarks to his Teacher Characteristic Study seem apropos to the results of the study just reported:

The data obtained and findings reported concerning teacher characteristics do not indicate what 'ought to be,' nor do they imply that what has been found is 'best' or 'true' once and for all. Teachers who currently are rated 'high' may manifest 'permissive, child-centered' educational viewpoints (or some other pattern of teacher behavior) simply because their experiences have been oriented in this direction; that is, because they have been taught to adopt such attitudes or behaviors.

. . . the hazards involved in the application of most behavioral research findings to individual cases should be stressed again. For a group of 500 teachers, considered as a group and viewed actuarially, a principle of teacher behavior may be stated with rather high assurance; for the same behavior such a statement or prediction with regard to individual teacher A may be made with a probability only slightly better than chance and therefore with substantially reduced assurance [p. 100].

LIMITATION OF THE STUDY

The most significant limitation is the ex post facto nature of this study. The hypotheses seek to find relationships between the variables, not causes of student achievement. Even though significant relationships were found between teacher interaction characteristics and pupil achievement, caution must be exercised to allow for causal factors other than those included in this study.

The teachers were not trained to enact particular patterns of behavior. The differences in the indirect and direct quality of teacher behavior were those that occurred naturally. If the teachers were trained

to provide more dramatic differences in their behavior (i.e., role playing in an experimental setting), there might be greater differences in the pupils' achievement.

The accessible population includes only those grade six students on the new elementary science program. Within the Separate school system, twenty-three schools out of the total of fifty-six schools are on the new science program. Because each of these twenty-three schools volunteered to adopt the new curriculum, the target population is limited to the grade six students within these particular schools.

It should be noted that the collection of data using Flanders' technique has a number of shortcomings. For instance, non-participating students (groups and/or individuals) are not always detected in the data. What may appear by the data to be a very active classroom may in fact involve only the teacher and a few verbose individual pupils. An attempt was made to gather information on the percentage of pupil involvement in verbal interaction. However, the effort was soon abandoned. A team of observers would have been required to gain, simultaneously, Flanders' data and extent of student involvement.

Another criticism that may be directed toward this study involves the instrument used for measuring the inquiry skills. Originally the writer had planned to use Butts' (1966) TAB test as a posttest and the STEP science test as a pretest. Correspondence with Butts, at the University of Texas, suggested that the TAB test was in a state of flux, that changes were being made. Butts suggested that the best test available to test the inquiry skills in science would be the STEP science test. Correspondence with Mayor, of the American Association for the Advancement of Science (AAAS), indicated that the AAAS test of the inquiry skills

would be available from the Xerox Corporation of New York. But Caisson, of Xerox Corporation of New York, stated that only the AAAS test for the primary level would be available in 1969. The decision had to be made, then, to use the STEP test as a posttest and to collect pupil IQ as a control for class differences.

IMPLICATIONS FOR FURTHER EDUCATIONAL RESEARCH

There is, no doubt, a need for much research into the identification of the factors involved in effective teaching behaviors. This is especially true for identifying appropriate teaching methods and behaviors which result in the development of inquiry skills in elementary science, social studies, and mathematics.

For example, a study could be undertaken similar to the one just reported but with a number of improvements:

1. Selection of a larger target population involving other grade levels.
2. Selection of urban and rural teachers and pupils.
3. Selecting a minimum of fifteen teachers in the sample.
4. Use of Hough's (1960) Observational System for the Analysis of Classroom Interaction rather than Flanders Interaction Analysis.
5. Use of other measures of effective teaching behaviors in conjunction with Hough's interaction categories. These measures could include McGee's (1955) California F Scale, Cook's (1951) Minnesota Teacher Attitude Inventory, Hough's (1965) Teacher Situation Reaction Test, Anderson's (1960) Our-Class Questionnaire, and/or Ryans' (1960) Teacher Characteristics Schedule.
6. Use of a number of trained observing teams to record interaction

data and percentage of pupil involvement in the classroom interaction.

7. Use of the AAAS inquiry test and the TAB test to measure the development of process skills in science.

8. Use of a design involving a longitudinal study of, perhaps, two years duration whereby the pupil-teacher class would remain as a group for the two year period.

9. Control for environmental factors, such as the pupil's home background and his educational background, in the regression analyses.

As a second example, a study could be undertaken at the university level involving practice teachers. Using such techniques as micro-teaching, video-taping, and interaction analysis in conjunction with the laboratory approach to the teaching of science, the effect of objective feedback to the practicing teacher could be studied. This study could involve an examination of the effect and possible changes occurring in the teacher's behaviors as a result of the feedback information given to the teacher.

As a third example, a study could be undertaken to study the interaction between teacher verbal interaction patterns and methods of teaching inquiry in science. The methods of teaching inquiry could reflect Bruner's (1961) hypothetical and expository modes, or Suchman's (1960) silent film-loop technique, or Scott's (1966) inquiry training approach. The research might involve four groups of specially-trained teachers:

Group 1 - Indirect, flexible teachers

Hypothetical mode

Group 2 - Direct, inflexible teachers

Hypothetical mode

Group 3 - Indirect, flexible teachers

Expository mode

Group 4 - Direct, flexible teachers

Expository mode

Implied in the formation of these groups is the hypothesis: the pupils whose teacher uses an hypothetical mode in an indirect, flexible manner will achieve higher in inquiry skills in science.

IMPLICATIONS FOR EDUCATIONAL PRACTICE

The introduction of a new elementary science program with the development of inquiry skills as a major goal has necessitated a realignment in the teaching behaviors of many teachers.

The results of this study offer a number of suggestions to the incumbent teacher:

1. Inquiry development in pupils may be enhanced by using an indirect approach especially when introducing new material. The indirect approach is reflected in a number of verbal skills (Amidon and Flanders, 1967):

- (a) ability to accept, clarify, and use ideas,
- (b) ability to accept and clarify emotional expression,
- (c) ability to relate emotional expression to ideas,
- (d) ability to state objectively a point of view,
- (e) ability to reflect accurately the ideas of others,
- (f) ability to summarize ideas presented in group discussion,
- (g) ability to communicate encouragement,
- (h) ability to question others without causing defensive behavior,
- (i) ability to use criticism with the least possible harm to the status of the recipient [p. 3].

2. Flexibility in teaching behaviors (characterized by adopting the verbal interaction patterns to suit the nature of the lesson at hand) may result in more effective teaching of the inquiry skills.

3. Opportunities for pupils to express themselves verbally

in a supportive classroom environment appears to be essential for inquiry development.

The results of this study have implications for preservice and inservice education. Teacher-training centres might consider the introduction of the analysis of verbal interaction as part of the education received by elementary school science teachers. The practicing teacher, versed in science content and methods of inquiry, might well turn to a self-examination of his patterns of influence on his pupils. If a number of science teachers on a school's staff were to become skilled in the use of interaction analysis, the resulting inter-class and intra-class communication might very well result in an overall improvement in the teaching of all aspects of science.

The importance of equipment, supplies, and facilities for the effective teaching of inquiry in science is not to be minimized, nor is the provision for individual opportunities for independent scientific investigation. However, the teacher might well consider the effect of his verbal interaction patterns on the development of the process skills in science--throughout the school day--in all subject areas.

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APPENDICES

- A. Flanders Interaction Analysis
- B. Interaction Analysis Matrix
- C. Methods of Inquiry
- D. Sequential Test of Educational Progress-Science, Form 4A
- E. Scott's Reliability Coefficient
- F. Darwin's Chi-square Test
- G. An APL360/67 Program for Calculating Darwin's Chi-square
- H. Raw Matrices, Individual Teachers: Expressed as Per Cent

APPENDIX A

FIANDERS INTERACTION ANALYSIS

FLANDERS INTERACTION ANALYSIS

Interaction analysis is a technique for measuring the verbal behavior of teachers and pupils within the classroom setting. This analysis was developed by Flanders (1965) out of social psychological theory and was designed to test the effect of social-emotional climate on student attitudes and learning.

The basis of support for a theory of social-emotional climate has its roots in the work of many researchers over the past thirty years. One of the pioneers in this analysis of classroom interaction is Anderson (1939). His assessment of the integrative and dominative behavior of teachers in their contacts with children are, in a significant way, forebears of Flanders' constructs of indirect and direct teacher influence.

The autocratic-democratic dichotomy presented by Lewin, Lippitt, and White (1939) was another precursor of Flanders' concepts.

From the work of Withall (1949) came support that classroom climate could be assessed and described by means of a category system. The categories used by Withall are, in many ways, similar to those that are embodied in the Flanders' system.

Interaction Process Analysis, as a research technique, was used by Bales and Strodtbeck (1951) in their search for improved understanding of the relationship between the behavior of group members and the productivity of groups.

Altogether, the research projects mentioned above define two teacher behavior patterns that create contrasting classroom climates:

Integrative Pattern (democratic, student-centered, indirect influence)

Dominative Pattern (authoritarian, teacher-centered, direct influence)

-
1. Accepts, clarifies, and supports the ideas and feelings of pupils.
 2. Praises and encourages.
 3. Asks questions to stimulate pupil participation in decision making.
 4. Asks questions to orient pupils to schoolwork.
-

1. Expresses or lectures about own ideas or knowledge.
 2. Gives directions or orders.
 3. Criticizes or deprecates pupil behavior with intent to change it.
 4. Justifies his own position or authority.
-

Amidon and Flanders (1967) describe the Flanders' system of interaction analysis:

The Flanders system is concerned with verbal behavior only, primarily because it can be observed with higher reliability than can nonverbal behavior. The assumption is made that the verbal behavior of any individual is an adequate sample of his total behavior.

In the Flanders system of interaction analysis all teacher statements are classified first as either indirect or direct. This classification gives central attention to the amount of freedom the teacher grants to the student. In a given situation, therefore, a teacher has a choice. He can be direct, that is, minimizing the freedom of the student to respond. His choice, conscious or unconscious, depends upon many factors, among which are his perceptions of the situations and the goals of the particular learning situation.

In order to make total behavior or total interaction in the classroom meaningful, the Flanders system also provides for the categorizing of student talk. A third major section, that of silence or confusion, is included in order to account for the time spent in behavior other than that which can be classified as either teacher or student talk. All statements that occur in the classroom, then, are categorized in one of three major sections: (a) teacher talk, (b) student talk, and a separate category, (c) silence or confusion, used to handle anything else that is not teacher or student talk.

The larger sections of teacher and student verbal behavior are subdivided in order to make the total pattern of teacher-pupil interaction more meaningful. The two subdivisions for verbal behavior; indirect and direct teacher talk, are further

divided into smaller categories. Indirect influence consists of four observation categories: (1) accepting feeling, (2) praising or encouraging, (3) accepting ideas, and (4) asking questions. Direct influence is divided into three categories: (5) lecturing, (6) giving directions, and (7) criticizing or justifying authority. Student talk is divided into only two categories: (8) responding to teachers, and (9) initiating talk. All categories are mutually exclusive, yet totally inclusive of all verbal interaction occurring in the classroom [pp. 121-122].

A summary of the ten categories, just described, appears in Figure 11.

Amidon and Flanders outline the procedure for categorizing teacher-pupil interaction:

Every three seconds the observer writes down the category number of the interaction he has just observed. He records these numbers in sequence in a column. He will write approximately 20 numbers per minute; thus, at the end of a period of time, he will have several long columns of numbers. The observer preserves this sequence of numbers that he has recorded. It is important to keep the tempo as steady as possible, but it is even more crucial to be accurate. He may also wish to write down marginal notes from time to time, which can be used to explain what has been happening in the classroom.

No matter whether he is using a live classroom or a tape recording for his observations, it is best for the observer to spend five or ten minutes getting oriented to the situation before he actually begins to categorize. He then has a feeling for the total atmosphere in which the teacher and pupils are working. After he has begun to get the feeling of the classroom interaction, he begins to record the interaction.

The observer stops classifying whenever the classroom activity is changed so that observing is inappropriate as, for instance, when there are various groups working around the classroom, or when children are working on workbooks or doing silent reading. He will usually draw a line under the recorded numbers, make a note of the new activity, and resume categorizing when the total class discussion continues. At all times the observer notes the kind of class activity he is observing. The reading group in the elementary school is obviously different from an informal discussion period, a review of subject matter, a period of supervised seat work, teacher-directed discussion,

introduction of new material, or evaluation of a complete unit. Such diverse activities may be expected to show different types of teacher-pupil interaction even when guided by the same teacher. A shift to new activity should also be noted [pp. 125-126].

TEACHER TALK	INDIRECT INFLUENCE	1. ACCEPTS FEELING: accepts and clarifies the tone of feeling of the students in an unthreatening manner. Feelings may be positive or negative. Predicting or recalling feelings are included. 2. PRAISES OR ENCOURAGES: praises or encourages student action or behavior. Jokes that release tension, but not at the expense of another individual, nodding head or saying "um Hm?" or "go on" are included. 3. ACCEPTS OR USES IDEAS OF STUDENT: clarifying, building, or developing ideas suggested by a student. As teacher brings more of his own ideas into play, shift to category 5. 4. ASKS QUESTIONS: asking a question about content or procedure with the intent that a student answer.
	DIRECT INFLUENCE	5. LECTURING: giving facts or opinions about content or procedure; expressing his own ideas, asking rhetorical questions. 6. GIVING DIRECTIONS: directions, commands, or orders which students are expected to comply with. 7. CRITICIZING OR JUSTIFYING AUTHORITY: statements intended to change student behavior from unacceptable to acceptable pattern; bawling someone out; stating why the teacher is doing what he is doing; extreme self-reference.
STUDENT TALK		8. STUDENT TALK--RESPONSE: talk by students in response to teacher. Teacher initiates the contact or solicits student statement. 9. STUDENT TALK--INITIATION: talk initiated by students. If "calling on" student is only to indicate who may talk next, observer must decide whether student wanted to talk.
SILENCE		10. SILENCE OR CONFUSION: pauses, short periods of silence and periods of confusion in which communication cannot be understood by the observer.

FIGURE 11

Summary of Categories for Interaction Analysis

APPENDIX B

INTERACTION ANALYSIS MATRIX

INTERACTION ANALYSIS MATRIX

Recording Data in a Matrix (Amidon and Flanders, 1967)

There is a method of recording the sequence of events in the classroom in such a way that certain facts become readily apparent. This method consists of entering the sequence of numbers into a 10-row by 10-column table, which is called a matrix (see Table XIII). The generalized sequence of the teacher-pupil interaction can be examined readily in this matrix. The following example shows how an observer would classify what happens in a classroom and how the observations are recorded in the matrix. The example is a fifth-grade teacher who is beginning a social studies lesson. The observer has been sitting in the classroom for several minutes and has begun to get some ideas of the general climate before he begins to record. The teacher says to the class, "Boys and girls, please open your social studies books to page 5." (Observer classified this as a 6, followed by a 10, because of the period of silence and confusion as the children try to find the page.) The teacher says, "Jimmy, we are all waiting for you. Will you please turn your book to page 5?" (Observer records a 7 and a 6.) "I know now," continues the teacher, "that some of us had a little difficulty with, and were a little disturbed by, the study of this chapter yesterday; I think that today we are going to find it more exciting and interesting." (Observer records two 1's; reacting to feeling.) "Now, has anyone had a chance to think about what we discussed yesterday?" (Observer records a 4 for a question.) A student answers, "I thought about it, and it seems to me that the reason we are in so much trouble in southeast Asia is that we haven't had a chance to learn to understand the ways of the people who live there." (Observer records three 8's.)

The teacher responds by saying, "Good, I am glad that you suggested that, John. Now let me see if I understand your idea completely. You have suggested that if we had known the people better in southeast Asia, we might not be in the trouble we are in today." (This is classified as a 2, followed by two 3's.)

The observer has now classified the following sequence of numbers in this fashion:

	10	4	
	) 1st pair	9	
	6	9	
2nd pair (		9	
	10	2	
	) 3rd pair	3	
	7	3	
4th pair (		10	
	6		
	1		
	1		

(The use of a 10 at the beginning and end of the sequence is explained in the discussion that follows.)

Tabulations are now made in the matrix to represent pairs of numbers. Notice in the listing above that the numbers have been marked off in pairs. The first pair is 10-6; the second pair is 6-10; etc. The particular cell in which tabulation of the pair of numbers is made is determined by using the first number in the pair to indicate the row and the second number in the pair for the column. Thus, 10-6 would be shown by a tally in the cell formed by Row 10 and Column 6. The second pair, 6-10, would be shown in the cell formed by Row 6 and Column 10. The third pair, 10-7, is entered into the cell, Row 10 and Column 7. Notice that each pair of numbers overlaps with the previous pair, and each number, except the first and the last, is used twice. It is for this reason that a 10 is entered as the first number and the last in the record. This number is chosen as it is convenient to assume that each record began and ended with silence. This procedure also permits the total of each column to equal the total of the corresponding row [pp. 128-130].

TABLE XIII

SAMPLE INTERACTION MATRIX

Second

First		1	2	3	4	5	6	7	8	9	10	Total
	1	1			1							
	2			1								
	3			1							1	
	4								1			
	5											
	6	1									1	
	7						1					
	8		1						11			
	9											
	10						1	1				
	Total	2	1	2	1	0	2	1	3	0	2	14

Indirect-Direct Ratio (I/D)

The ratio of a teacher's indirect verbal influence to his direct verbal influence may be calculated by dividing the sums of columns 1, 2, 3, and 4 by the sums of columns 5, 6, and 7.

For Table XIII, the teacher's I/D:

$$\frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{2 + 1 + 2 + 1}{0 + 2 + 1} = \frac{6}{3} = 2.0$$

Per Cent Teacher Talk

The percentage of the classroom time that the teacher was talking may be calculated by dividing the sums of columns 1-7 by the sums of columns 1-10.

For Table XIII, the per cent teacher talk:

$$\frac{\text{Column 1-7}}{\text{Column 1-10}} = \frac{9}{14} \times 100\% = 64.29\%$$

Per Cent Pupil Talk

The percentage of the classroom time that the pupils were talking may be calculated by dividing the sums of columns 8-9 by the sums of columns 1-10.

For Table XIII, per cent pupil talk:

$$\frac{\text{Column 8-9}}{\text{Column 1-10}} = \frac{3}{14} \times 100\% = 21.43\%$$

Per Cent Silence

The percentage of the classroom time that there was silence or confusion may be calculated by dividing the sum of column 10 by the sums of columns 1-10.

For Table XIII, per cent silence:

$$\frac{\text{Column 10}}{\text{Column 1-10}} = \frac{2}{14} \times 100\% = 14.28\%$$

APPENDIX C

METHODS OF INQUIRY

(From the Curriculum Guide for
Elementary School Science,
1968, pp. 10-14)

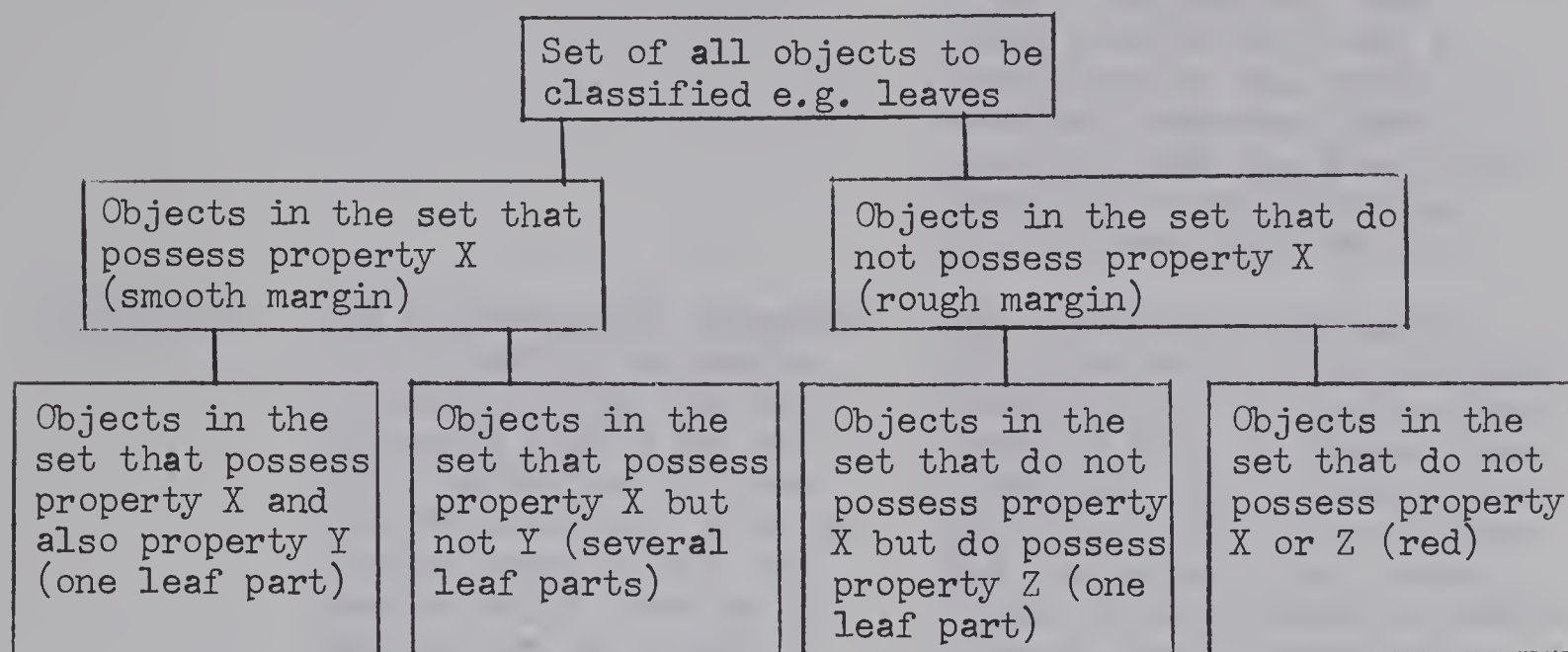
THE TWELVE BASIC PROCESS SKILLS

(Methods of Inquiry)

Process	Description of Behavior	Example Activities
Observing	The desired pupil behavior is increasing competence in using not only his sense of sight but also his other senses of hearing, touch, smell and taste.	These may involve both oral and written descriptions of the following: Identify and name colors, textures, relative sizes and other properties of objects. Distinguish differences in temperature, read temperature on a thermometer; identify and name factors in weather such as temperature and precipitation; identify possible causes of change, such as heat, wind and air pressure, show the effect or cause of change on an object such as a balloon: describe selected items so that others can identify and name them; identify and name the main parts of a plant; describe plant growth over a period of time; describe the relationship between two variables.
Classifying	The desired pupil behavior is increasing competence in grouping articles, objects and ideas on the basis of some observable property or properties.	Objects may be classified according to smoothness, texture, color, and special characteristics. Single stage classification are followed by two-stage and multi-stage classifications, as shown in the following illustrative sequence.

Process	Description of Behavior	Example Activities
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Two-Stage Classification System



Quantifying	The desired pupil behavior is increasing competence in measuring length, weight, area, volume, and rate of change of the physical world.	The following are illustrative: Distinguish objects by using such terms as heavier and lighter; identify relative weight by lifting; use a balance to distinguish heavier from lighter objects; use standard units of weight; explain effects of gravitation and inertia; measure the weight of various objects; describe differences in weight; identify, state and demonstrate differences in perception of weight.
Communicating	The desired pupil behavior is increasing competence in describing an experiment so that an individual who has not seen it can carry it out.	Experience in identifying and naming objects are followed by graphing and describing measured changes as shown in the following example: Identify and name events that can be quantified, such as five bounces of a ball; make a column in a bar graph to represent the frequency of an event; distinguish events shown in a graph; make a bar graph; describe measured changes in

Process	Description of Behavior	Example Activities
		speed, temperature, and other properties; make a prediction on the basis of recorded measures; make a graph to show the prediction; describe an experiment so that others might do it.
Inferring	The desired pupil behavior is increasing competence in drawing more than one inference from a set of data, demonstrating that inference can be tested by further observation, and demonstrating that an inference can be tested by applying known tests to the properties of objects. Pupils should indicate that they are able to distinguish between observations and inferences.	The following sequence is illustrative: Use the concept "evaporation" to explain how water is lost by plants; demonstrate a way to measure the water used by a plant; infer and demonstrate that water drawn through plants is transferred to the atmosphere; show that an inference may be tested by additional observations.
Predicting	The desired pupil behavior is increasing competence in conducting experiments to test predictions of relationships between two measurable quantities.	Various tasks might include: plotting data, making and interpreting graphs, and observing from different vantage points. For example, analyze a graph to determine the pattern of relationships (increasing, decreasing, stable); use a graph to predict water loss from plants; make predictions from a series of observations by means of graphs; conduct an experiment to test predictions.

Integrated Processes

Six integrated processes that build upon the basic processes are indicated in the following table:

Formulating Hypotheses	The desired pupil behavior involves developing increasing competence in stating a hypotheses regarding causes of a phe-	The following illustrate hypotheses: 1. If the air pressure inside the tube is less than the air pressure outside the
------------------------	---	--

Process	Description of Behavior	Example Activities
	nomenon or the relationship between two variables. A hypothesis tells how to observe an expected outcome of an experiment.	tube, then the water will rise in the tube. 2. If a ball is dropped, its speed will increase as it approaches the floor.
Making Operational Definitions	The pupil should demonstrate increasing competence in stating the minimum things to do or look for in order to identify the subject being defined.	The following are illustrative: Cold means 15° C for this experiment; little friction means that not more than an additional 10% of force over and above the weight of the object is required to move the objects across a surface.
Controlling and Manipulating Variables	The desired pupil behavior is increasing competence in arranging conditions so as to be able to deliberately control and manipulate objects or conditions in an experiment.	The following examples are illustrative: 1. Consider two pendula swinging at different rates. Variables to control might include: the weights, (size, shape, and mass), the string (length and thickness), and the length of swing. 2. Metals expand when heated. Variables to control might include: temperature of flame, nature of materials, wind, etc.
Interpreting Data	The desired pupil behavior is increasing competence in getting the most out of data without oversimplifying, drawing conclusions supported by the data, and considering alternative explanations.	Interpretations may be made of observations made in the form of verbal statements, graphs, histograms and tables.
Formulating Models	The desired pupil behavior is increasing competence in building both physical and mental models to account for phenomena.	The following models are illustrative: 1. Pictures of the moon's surface. 2. Diagrams of the life cycle of an insect. 3. Physical model of a chromosome. 4. Mental model - idea of an atom.

Process	Description of Behavior	Example Activities
Experi- menting	The desired pupil behavior is increasing competence in planning, conduction and communicating experiments in which the problem is clarified, hypotheses are stated, observations are made, and data is interpreted. This process depends upon the pupil being able to use all of the other processes.	Pupils might develop experiments to answer the following questions: 1. How do mealworms react to light? 2. How many nails can a magnet lift? 3. What happens to salt when it is placed in water? Does more salt dissolve in water at 35° than at 20° C?

APPENDIX D

SEQUENTIAL TEST OF EDUCATIONAL
PROGRESS - SCIENCE, FORM 4A

Cooperative

*Sequential
Tests of
Educational
Progress*

Science



General Directions

This is a test of some of the understandings, skills, and abilities you have been developing ever since you first entered school. You should take the test in the same way that you would work on any new and interesting assignment. Here are a few suggestions which will help you to earn your best score:

1. Make sure you understand the test directions before you begin working. You may ask questions about any part of the directions you do not understand.
2. You will make your best score by answering *every* question because your score is the number of correct answers you mark. Therefore, you should work carefully but not spend too much time on any one question. If a question seems to be too difficult, make the most careful guess you can, rather than waste time puzzling over it.
3. If you finish before time is called, go back and spend more time on those questions about which you were most doubtful.

DIRECTIONS FOR PART ONE

Each of the questions or incomplete statements in this test is followed by four suggested answers. You are to decide which one of these answers you should choose.

You must mark all of your answers on the separate answer sheet you have been given; this test booklet should not be marked in any way. You must mark your answer sheet by blackening the space having the same letter as the answer you have chosen. For example:

- 0** Which one of the following is an animal?
- A** Bed
 - B** Dog
 - C** Chair
 - D** Box

Since a dog is an animal, you should choose the answer lettered **B**. On your answer sheet, you would first find the row of spaces numbered the same as the question—in the example above, it is **0**. Then you would blacken the space in this row which has the same letter as the answer you have chosen. See how the example has been marked on your answer sheet.

Make your answer marks heavy and black. Mark only one answer for each question. If you change your mind about an answer, be sure to erase the first mark completely.

PART ONE

FUN AT CAMP

Jack, Bobby, Joe, and Harry went to a summer camp. At the camp many interesting things happened to them.

- 1 Early one morning as the boys hiked through the fields, their feet became very wet. The night had been cooler, but there had been no rain. They wondered where the water on the grass came from. Which boy gave the right answer?

A Jack said the water came from the soil under the plants.
B Bobby said the water came from the leaves of the plants.
C Joe said the water came from the clouds over the plants.
D Harry said the water came from the air around the plants.

- 2 Late one afternoon, the boys watched a thunderstorm from the game room. After each flash of lightning they heard thunder. They talked about it and wondered why the lightning came first. Who was right?

E Jack said it was because the lightning flash hits the earth.
F Bobby said it was because light travels faster than sound.
G Joe said it was because the thunder is slowed down by the clouds.
H Harry said it was because the lightning is reflected from the clouds.

- 3 The storm caught a group of hikers in the middle of a large open field far from camp. The best thing for the boys to have done to keep from being hit by lightning would have been to lie flat on the ground. This would help to protect them from lightning because

A lightning usually strikes the high points
B the wet grass would protect them from the electricity
C water does not conduct electricity
D they were tired and could not run for the trees

- 4 The boys came out of the water swimming one windy day. In order to get dry most quickly, they should have
- E** stood in the shade and let the wind dry them
F stood in the sun to dry
G rubbed themselves dry with towels
H played a game of tag
- 5 Harry wondered if sound is able to travel through water. To prove that sound can travel through water, he should
- A** ask his lifeguard or parents
B hit two stones together above the water of the lake and listen to the sound
C put his ear next to the water of the lake and hit two stones together above the water
D put his head under the water of the lake and hit two stones together in the water
- 6 Jack was curious about the birds and wondered whether many of them stayed near the campgrounds through the winter. Jack could do as he pleased, what would be the best way to find out which birds stayed near the campgrounds?
- E** Study the birds which are near the campgrounds at different seasons.
F Read a book about birds that migrate.
G Watch the birds through binoculars and study their flight.
H Talk to people who live near the campgrounds.
- 7 On one of their hikes, the boys found a path blocked by a fallen tree. When they walked on it, the tree fell apart under their feet. This happened because
- A** the tree trunk was small
B the tree was dead
C the inside of the tree had rotted away
D the tree had soaked up a lot of water from the ground

SICK IN BED

On a cold winter day, Jane didn't feel well and was very cross. Mother kept her home school, so her brother Bill went to school without her. When Mother looked at Jane's forehead, she found that it was red and sore.

Mother wondered if Jane had a fever. The quickest way for Mother to learn if Jane had a fever was to

- Feel Jane's head
- Ask Jane if she felt hot
- Look at Jane's tongue
- Look at Jane's eyes

Mother found that Jane had a fever. She knew this because the thermometer

- Read below 98 degrees
- Read 98 degrees
- Read 101 degrees
- Did not change its reading in Jane's mouth

Mother kept a record of Jane's temperature for two days. This is the way the record looked:

	Morning	Noon	Night
Monday	101°	101°	102°
Tuesday	100°	99°	98°

From the chart you can tell that Jane's temperature was highest at

- Noon on Monday
- Night on Monday
- Noon on Tuesday
- Night on Tuesday

When Bill came home from school, Mother looked at his throat and took his temperature, too. Mother did this because

- Children often catch a disease from someone who is ill
- Bill went to school with other children
- It was cold outside
- Bill's shoes were wet from playing in the snow

12 Jane called to Bill from the bedroom, "Please come sit here on my bed and play with me." Mother would not let Bill be close to Jane because Jane was

- E cross
- F coughing and sneezing
- G unhappy
- H younger than Bill

BICYCLE RIDE

13 Before taking a ride on his bicycle, Tony always inspected it. One day he found that his front tire was soft. He used his hand pump to put more air in the tire. After a while he found that it became harder to use the pump. This was because the

- A air in the tire pushed against the pump
- B air started to leak out of the pump
- C pump got too hot to hold
- D pump got too sticky to push

14 While Tony was inspecting his bike, he also looked over the wheels. Why did he run his fingers over all the spokes?

- E To straighten the bent spokes
- F To find out from the sound of the spokes if they were tight
- G To loosen up the tight spokes which were making the wheel wobble
- H To make the spokes more springy for the ride

15 One day it suddenly started to rain while Tony was riding his bike. In order to get home quickly and safely, which one of these things should he NOT do?

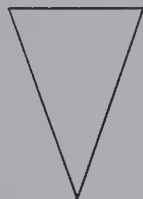
- A Put the brakes on gradually before making a turn.
- B Slow down at crossings to make sure there are no cars coming from other directions.
- C Stay on the proper side of the road.
- D Ride close behind a truck to keep off the rain.

- 16** Tony's tires became smooth. All the tread was worn off. What is the best reason why he should get new tires for his bicycle?
- E** To improve the looks of his bicycle
 - F** To help him stop more quickly
 - G** To help him travel faster on level ground
 - H** To help him travel faster going downhill
- 17** Father told Tony he should always wear white shirts or white sweaters when he rides his bicycle at night. White clothing is best because it
- A** is cooler than dark clothing
 - B** is warmer than dark clothing
 - C** reflects light better than dark clothing
 - D** is cleaner than dark clothing

THE JACKSON GARDEN

Tom and Alice Jackson help to plant a garden every spring.

- 18** They have many kinds of garden tools. What is the main job of the tools which are wedge-shaped like the drawing?



- E** Breaking up soil
 - F** Flattening soil
 - G** Moving soil
 - H** Packing down soil
- 19** After they bought seeds and prepared the soil, they got some string and stakes to mark out the rows. How should they decide the distance to leave between the rows of seeds?
- A** Leave room to walk between the rows.
 - B** Follow the instructions on the seed package.
 - C** Leave 12 inches between the rows of plants.
 - D** Find out how tall a plant grows.

- 20** Tom and Alice decided to plant carrots in their garden. Tom read from the back of the package of carrot seeds these following instructions: "Make sowings every two weeks up to early July; the last sowing will make full-sized roots for winter use." Why do you think the package says to plant several times instead of only once?
- E** Because the temperature is warm throughout the summer.
 - F** Because the amount of rainfall changes from week to week.
 - G** So that all the carrots would be ready to be grown at one time.
 - H** So that the gardener could have carrots all summer long.
- 21** Then Tom read, "When the plants are 2 inches up, thin them so that they are 12 inches apart in the row." Tom asked his father, "Why must I pull out some of the plants?" Which of the following answers do you think his father gave?
- A** The soil has too little plant food.
 - B** Many carrots grow in different directions.
 - C** Carrots need the additional space underground to grow and store food.
 - D** Some carrots are dwarf and some are giant carrots.
- 22** Which method would be best for Tom to use to keep several carrots when he wants to bring them in from the garden?
- E** Wrap them tightly in a plastic bag.
 - F** Place them in the home freezer.
 - G** Store them in a dry part of the kitchen.
 - H** Put them in a plastic bag in the refrigerator.

Tom wanted to learn which of three types of soil—clay, sand, or loam—would be best for growing lima beans. He found three flowerpots, put a different type of soil in each pot, and planted the same number of lima beans in each. He placed them side by side on the window sill and gave each pot the same amount of water.



The lima beans grew best in the loam. Why did Mr. Jackson say Tom's experiment was NOT a good experiment and did NOT prove that loam was the best for plant growth?

The plants in one pot got more sunlight than the plants in the other pots. The amount of soil in each pot was not the same.

One pot should have been placed in the dark.

Tom should have used three kinds of seeds.

Tom saw that moist clay stuck together tightly and dry clay was almost as hard as rock. The clay held the water so that the water did not run through. Why didn't the plants in the clay soil grow as well as the plants in the loam?

The roots lacked air and rotted.

The clay was dark in color.

The clay dried and cracks were formed.

There were no earthworms in the clay.

25 Tom and Alice watched the birds in their garden. Some of the birds they saw in the summertime were not in the garden in winter. They wondered what happened to them. Which of their friends gave the best answer?

- A Jack said, "The birds die because in winter there are no insects to eat."
- B Bill said, "Birds only live one summer."
- C Jane said, "The birds sleep all winter in a winter nest."
- D Ruth said, "The birds fly to a winter home in the warmer South."

A TRIP TO THE MOON

Joe, Judy, and their friends were playing in the back yard. They had made a spaceship from wooden boxes. Today they were making plans for their first trip to the moon. Judy said, "Scientists tell us that the moon has no atmosphere. We will need many things for our journey."

26 Jack asked, "If we were really on the moon, how could we keep in touch with each other as we explored?" Which one of the children's ideas is best?

- E Judy said, "Let's take a garden hose to use as a speaking tube."
- F Phil said, "Let's find out from Mr. Jones where he got his hearing aid. We could take some of those."
- G Joe said, "Let's make sure we take enough walkie-talkies with plenty of fresh batteries."
- H Betty said, "Let's bring along some large megaphones like the cheerleaders use."

27 After they had landed on the moon, what would they most need to have before they could leave their spaceship?

- A Food that would give them plenty of energy
- B Warm clothing to protect them from the cold
- C Raincoats and rubbers in case of a moon storm
- D Tanks of air for their space suits

- 28** Judy said that she had read that the gravity of the moon is much less than the gravity of the earth. She said that when they land on the moon, they will find it easy to
- E** jump very high
 - F** light their campfire
 - G** fly their kites
 - H** measure their weights
- 29** On the imaginary trip, the space travelers decided to go from the moon to Mars. They wondered what kind of life they would find there. Which idea do you think is the best?
- A** Phil thought that living things on Mars would be similar to those on earth because the atmosphere is similar.
 - B** Alice thought that there would be green-skinned people.
 - C** Joe said that the people who live on Mars would have popping eyes and big heads.
 - D** Judy thought that they wouldn't know for sure until they got there.
- 30** The greatest problem for all space travelers would be the problem of
- E** escaping from the pull of the earth
 - F** taking the right kind of food
 - G** carrying the right clothing
 - H** taking the right kind of fuel to cook their food



Stop. If you finish before time is called, check your work on this part. Do not go on to Part Two until you are told to do so.

DIRECTIONS FOR PART TWO

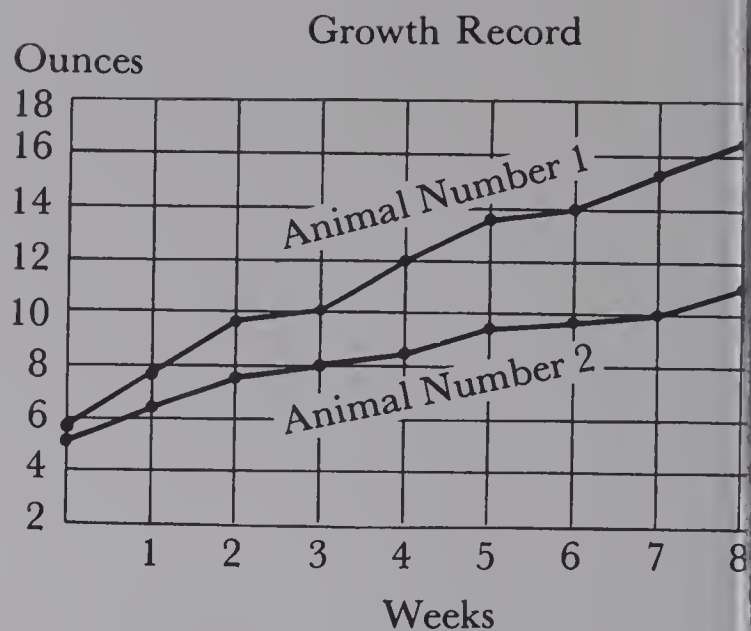
Part Two contains the same kind of material as Part One. Mark your answers in the same way.

PART TWO

PETS IN CLASS

Miss Damrin's class kept several pets in their classroom.

- 1 One afternoon they were looking at the beautiful, tiny, tropical fish in the aquarium. Jane asked, "Why is the water heated for these fish?" Which pupil gave the best answer?
 - A Tom said, "To keep the water from freezing."
 - B Bill said, "To kill harmful germs which might be in the water."
 - C Ruth said, "To keep the water clean and clear for the fish."
 - D Bob said, "To give the fish the kind of home in which they can best live."
- 2 For their classroom, Ruth's father gave the children two cages and two little guinea pigs which were the same size. They wanted to find out if dark whole-wheat bread is better for health and growth than white bread. How could they best carry out their experiment?
 - E Give both guinea pigs white bread.
 - F Give both guinea pigs whole-wheat bread.
 - G Give one guinea pig whole-wheat bread and the other white bread.
 - H Give one guinea pig whole-wheat bread, and the other no bread at all.
- 3 Bill's father also gave the class a pair of guinea pigs. The children gave the two guinea pigs different diets. The children weighed their guinea pigs each Friday. They kept a growth record. This is their chart.



- From this chart, can you tell what happened to the guinea pigs?
- A Both gained the same amount of weight.
 - B Number 1 gained more than number 2.
 - C Number 2 gained more than number 1.
 - D Number 2 lost weight.
- 4 From this chart what was the difference in weight between the two guinea pigs after nine weeks?
 - E Number 1 weighed 6 ounces more than number 2.
 - F Number 1 weighed 18 ounces more than number 2.
 - G Number 2 weighed 6 ounces more than number 1.
 - H Number 2 weighed 12 ounces more than number 1.
 - 5 Mary took one guinea pig home from school and fed him properly over the weekend. The guinea pig lay quiet and rested on the bottom of the cage. Billy took the other one home. He forgot to feed it on Monday morning. The guinea pig was restless, ran around the cage, and bit Billy's finger. What do you think the children learned?
 - A Guinea pigs can live for days without food.
 - B Guinea pigs sleep when they are hungry.
 - C Guinea pigs fight each other for food.
 - D Hunger changes a guinea pig's actions.

Miss Damrin asked the class, "What kind of animal do you think scientists must use in their work when they are trying to learn more about foods, drugs, and the health of people?"

- E** An animal that is cheap
- F** An animal that is small and easy to keep in the laboratory
- G** An animal that lives a long time
- H** An animal similar in structure to people

Miss Damrin said, "Dogs, cats, rabbits, mice, and guinea pigs are members of the same group of animals." Why is this true?

- A** They can all make noises and protect themselves from enemies.
- B** They can all feed their babies with milk from the mothers' bodies.
- C** They can all breathe and move.
- D** They can all eat food and grow larger.

MAKING CANDY

On a cold rainy afternoon, Bob and Mary decided to make candy. They needed sugar, butter, chocolate, and nuts.

Mary heated and stirred two cups of water and four cups of sugar in a pan. What do you think happened to the sugar?

- E** All the sugar dissolved in the water.
- F** None of the sugar dissolved in the water.
- G** The sugar and water together made about six cups of mixture.
- H** The sugar melted.

Mary put two squares of hard, bitter chocolate into the boiling mixture. Tom added four tablespoons of butter at the same time. Even though the amount of chocolate and the amount of butter were about the same, the butter melted before the chocolate. This happened because

- A** heat melts some solid things to liquids.
- B** each kind of solid needs a different amount of heat to make it melt.
- C** some solids melt in boiling water.
- D** the butter was warmer than the chocolate.

10 Mary heated the candy in the pan for 10 minutes after it began to boil. What happened to the mixture?

- E** It became a heavy syrup.
- F** It became very thin and watery.
- G** It became solid just after it boiled.
- H** Nearly all of the mixture boiled away.

11 Bob spread a thin coat of butter on his saucer. Mary did not. They poured the candy on the plates. What happened to the candy?

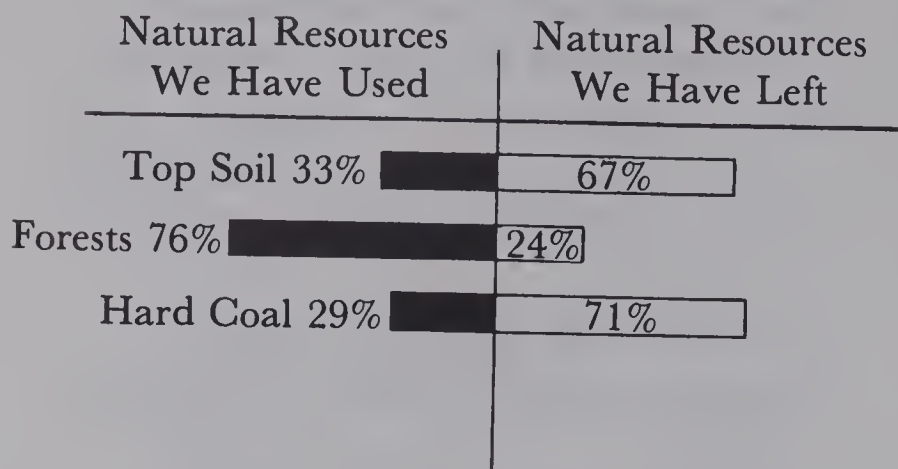
- A** Bob's candy stuck to his plate.
- B** Both children's candy stuck to their plates.
- C** Mary's candy stuck to her plate.
- D** The butter spoiled the candy.

12 The children set their plates of candy outside in the cold air. They did this because cold

- E** keeps the candy from sticking to the plate.
- F** makes many liquids become solids.
- G** keeps candy fresh longer.
- H** makes the water in the candy disappear.

A TRIP TO A NATIONAL PARK

The Taylor family spent their vacation at a lodge in a national park. The forest ranger showed the visitors at the lodge this graph:



13 The graph shows that we have most nearly used up our

- A top soil
- B hard coal
- C forests
- D oil

14 From the graph can we tell about how much of our rich top soil has been used up?

- E All of it
- F One-third of it
- G One-half of it
- H None of it

15 The ranger said every one must help *conserve* America's resources. By this he meant

- A to use none of the resources
- B to use all of the resources
- C to use the resources wisely
- D to sell the resources

16 The ranger showed the family the best way make a campfire. *First* he

- E loosely piled long, dry twigs into a cone shape
- F cleared brush and leaves from a space
- G placed large pieces of dry wood in a pile
- H poured gasoline on a pile of wood

17 The ranger said that boys and girls help to prevent forest fires by never *ing* a campfire while it is burning and putting out the campfire. They can put a campfire out by

- A stamping on the ashes of the fire
- B fanning the ashes of the fire with a newspaper
- C putting water or soil on the ashes of the fire
- D scattering the ashes of the fire

18 The forest ranger said that the weather bureau also helps fight forest fires. This is true because

- E weather forecasts tell the temperature of the air
- F weather forecasts tell the condition of the sky
- G weather forecasts tell the direction and speed of the wind
- H weather forecasts tell the time of sunrise and sunset

19 The ranger told the children that another way the weather bureau helps to prevent forest fires is by keeping a record of amount of rainfall. This is true because

- A much rainfall warns us that the forest will be wet
- B little rainfall warns us that the forest will be dry
- C much rainfall makes trees grow faster
- D much rainfall makes seeds begin to grow

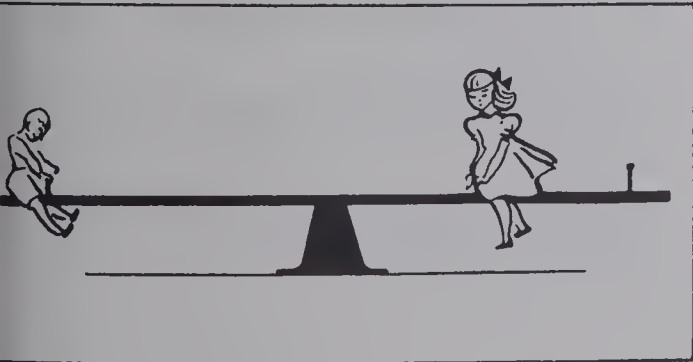
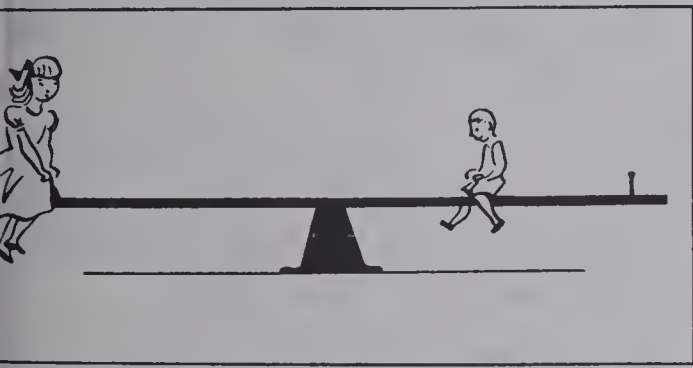
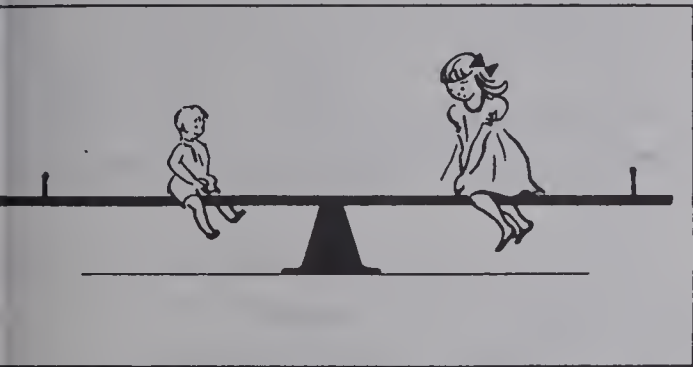
20 The forest ranger asked the family not to pick the wild flowers in the national park because

- E many wild flowers are poisonous
- F wild flowers wither and die very quickly after they are picked
- G flowers make seeds from which new plants grow
- H bees need the honey from wild flowers

THE PLAYGROUND

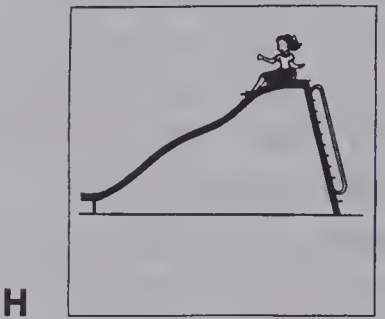
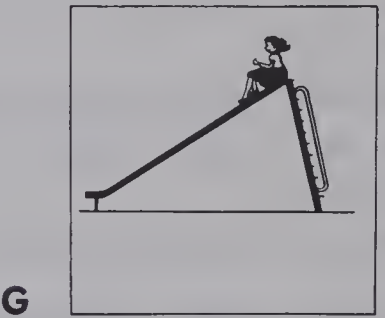
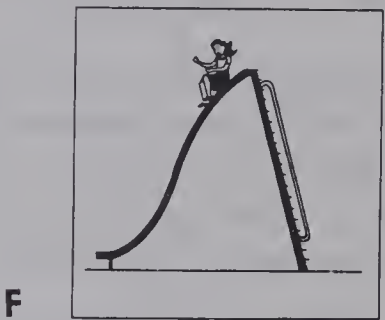
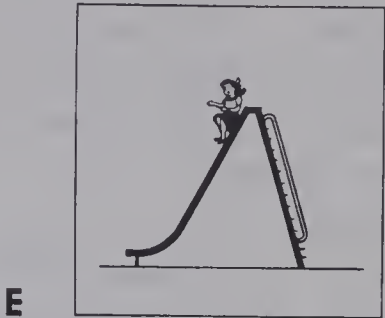
and her little brother, George, lived near playground in the park. One day Betty him to the playground.

George wanted to seesaw with Betty. Which picture shows the best way for Betty who weighed 100 pounds to balance George who weighed 50 pounds?



- A Picture A
- B Picture B
- C Picture C
- D Picture D

22 Betty saw the different slides on the playground and decided to try one. On which of the following slides would she be going the fastest at the end of her ride?



- E Picture E
- F Picture F
- G Picture G
- H Picture H

23 George played with a big rubber ball in the wading pool. He pushed it to the bottom of the pool. It came right back up. He asked his friends why it did this. Which boy gave the best answer?

- A** Tom said, "The ball floats because it is made of rubber which is light."
- B** Bill said, "The ball floats because it is big and round."
- C** John said, "The ball floats because it is made of waterproof rubber."
- D** Joe said, "The ball floats because it is hollow and filled with air."

24 Betty's dog jumped in the wading pool. He swam all the way across with the tip of his nose just above the water. Betty asked her friends why her dog couldn't swim underwater like the fish swam in the park pond. Which is the best answer?

- E** "Fish have tails and fins which help them swim."
- F** "Fish have scales on their bodies."
- G** "Fish have gills which take oxygen from water."
- H** "Fish have streamlined bodies."

25 George liked to play in the sandbox. The sand glistened in the sunlight. Betty said that sand is useful to people in the making of glass. George wondered how you could see through sand. How do you think sand can be used to make glass?

- A** By separating all the glistening, shining grains from the sand
- B** By adding chemicals to the sand and heating it
- C** By washing away the dirt from the sand
- D** By grinding it into finer grains of sand

THE DAIRY

Helen's class had been studying about dairies. They were pleased when Helen's father invited the class to visit the dairy in which he worked. He met the class at the dairy and took them on a tour through it.

26 The class saw thousands of milk bottles being washed in a machine. The class asked what they thought was the most important problem in washing bottles. Which do you think it is?

- E** To keep the bottles from breaking
- F** To kill germs in the bottles
- G** To make the bottles look clean
- H** To wash the bottles quickly

27 John saw that the cases of empty milk bottles were put on a moving belt. This belt carried the cases to the second floor where the bottles were filled. The most important reason for using the moving belt was that

- A** fewer people are needed to do the work
- B** it breaks few bottles
- C** it keeps the bottles clean
- D** it makes the dairy a quieter place in which to work

28 One of the wheels on the machine carrying cases of bottles started to squeak. The man put oil on the wheel. Which is the best reason for doing this?

- E** Oil cleans the wheel.
- F** It will prevent the machine from wearing out so soon.
- G** It will make the machine safer to operate.
- H** All moving metal parts need oil every day.

orge said that his doctor had told him
t milk may carry the germs of tubercu-
is. The best way for you to make sure
ur milk is free from disease-giving germs
o

drink only cold milk

drink only milk from nearby farms

drink only raw or unpasteurized milk

drink only pasteurized milk

etty told the class that she had heard
t pasteurized milk would never turn
r. Some of her classmates were uncer-
n about this. The best way to find out
uld be to

ask the man in charge of the dairy and
accept his answer

look up the answer in a dictionary

let the class vote on the question and
accept their opinion

put a bottle of pasteurized milk on
the window sill and look at it every day

**If you finish before time is called, you
may check your work on Part Two. Do
not go back to Part One.**

APPENDIX E

SCOTT'S RELIABILITY COEFFICIENT

RELIABILITY OF COLLECTING
FLANDERS INTERACTION DATA

Scott's Coefficient

Scott's (1955) coefficient is a measure of reliability of observers in their collection of verbal interaction data. According to Flanders (1965), Scott's method is "unaffected by low frequencies, can be adapted to per cent figures, can be estimated more rapidly in the field, and is more sensitive at higher levels of reliability [p. 25]."

Scott's coefficient (s) is determined by the two formulas below:

Formula I:
$$s = \frac{P_o - P_e}{1 - P_e}$$

P_o is the proportion of agreement, and P_e is the proportion of agreement expected by chance, which is found by squaring the proportion of tallies in each category and summing these over all categories.

Formula II:
$$P_e = \sum_{i=1}^k P_i^2$$

In Formula II there are k categories and P_i is the proportion of tallies falling into each category.

Scott's coefficient (s) may be described as the amount by which the tallies of two observers exceeded chance agreement, divided by the amount by which perfect agreement exceeds chance.

An APL/1500 Program for Calculating Scott's Coefficient

The writer has developed an APL/1500 program for calculating Scott's coefficient. A sample calculation appears in Table XIV.

TABLE XIV
CALCULATING RELIABILITY BY
SCOTT'S METHOD USING PER CENT

Category	Observer X	Observer Y	% X	% Y	% Diff.	(Ave.%) ² ÷ 100
APL/1500 Symbol	A	B	C	D	E	F
1	2	3	0.3289	0.4518	0.1229	0.00152
2	63	68	10.3618	10.2410	0.1209	1.06119
3	11	12	1.8092	1.8072	0.0020	0.03270
4	138	145	22.6974	21.8273	0.8600	4.95835
5	90	105	14.8026	15.8133	1.0106	2.34333
6	50	54	8.2237	8.1325	0.0912	0.66882
7	43	51	7.0724	7.6807	0.6083	0.54413
8	66	63	10.8553	9.4879	1.3673	1.03462
9	62	71	10.1974	10.6928	0.4954	1.09099
10	83	92	13.6513	13.8554	0.2041	1.89155
Total	608	664	100.0000	100.0000	4.8827	13.6272

The program for calculating Scott's coefficient appears below:

A ← observer X's tallies for each of the ten Flanders' categories

B ← observer Y's tallies for each of the ten Flanders' categories

C ← $A \times 100 \div (+/A)$ ← percentage of each category for observer X

D ← $B \times 100 \div (+/B)$ ← percentage of each category for observer Y

E ← $|(C-D)|$ ← absolute difference between C and D for a single category

$F \leftarrow ((C + D) \div 2) \times 2 \div 100 \leftarrow$ the square of the average per
cent of C and D divided by 100

$S \leftarrow ((100 - (+/E) - (+/F)) \div (100 - (+/F))) \leftarrow \frac{P_o - P_e}{100 - P_e} \leftarrow$

—— Scott's Coefficient

Using the figures in Table XIV, the program is illustrated below:

$$C \leftarrow 2 \div 608 \times 100\% = 0.3289\%$$

$$D \leftarrow 3 \div 664 \times 100\% = 0.4518\%$$

$$E \leftarrow 0.4518 - 0.3289 = 0.1229$$

$$F \leftarrow \frac{(0.3289 + 0.4518)^2}{2} \div 100 = 0.00152$$

$$S \leftarrow \frac{(100.0000 - 4.8827) - (13.6272)}{(100.0000 - 13.6272)} = 0.94347$$

The Scott's coefficient was calculated to be 0.943. This value indicates a high degree of agreement between the two observers, X and Y. It should be added that the agreement refers to frequency of tallies in the ten Flanders' categories. No test is available to measure the degree of agreement between sequences of recording interaction data.

APPENDIX F

DARWIN'S CHI-SQUARE TEST

PROCEDURE FOR TESTING THE SIGNIFICANT OF THE DIFFERENCE OF TWO MATRICES BY DARWIN'S METHOD

Computing Darwin's Chi-square

Given two or more matrices, the null hypothesis concerning the matrix distributions can be tested by a likelihood ratio criterion suggested by Darwin (Linnes, 1956).

$$2(\underbrace{\sum n_{jkl} \log_e n_{jkl}}_{(K)} - \underbrace{\sum n_{j.1} \log_e n_{j.1}}_{(L)} - \underbrace{\sum n_{jk.} \log_e n_{jk.}}_{(M)} + \underbrace{\sum n_{j..} \log_e n_{j..}}_{(N)})$$

This formula may be translated into words:

- Step One: Prepare a 10 x 10 matrix A and a second matrix B.
- Step Two: Prepare a third matrix C, which is a combination of A and B. The addition is performed cell by cell.
- Step Three: The first term, K, is found by multiplying each cell frequency by its own natural logarithm ($n \log_e n$), adding these 100 products from A to the 100 products from B, and the sum will then equal the first term K.
- Step Four: The second term, L, is found by multiplying each row total by its own natural logarithm, adding the 10 products from B, and the sum will then equal term L.
- Step Five: The third term, M, is found by multiplying each cell frequency in the C matrix by its own natural logarithm, adding the 100 products, and the total sum will then equal term M.

Step Six: The fourth term, N, is found by multiplying each row total of matrix C by its own natural logarithm, adding the 10 products, and the total will then equal term N.

Step Seven: The terms are combined as indicated, that is,

$$X = 2(K - L - M + N).$$

For two 10 x 10 matrices, this criterion has a sampling distribution of chi-square at 90 degrees freedom. Since chi-square approaches a normal distribution for higher degrees of freedom, the above criterion can be converted to a standard score as follows:

$$Z = \frac{\sqrt{2X^2}}{\sqrt{2n - 1}}, \text{ where } n \text{ equals the number of degrees of freedom and } X^2 \text{ is Darwin's chi-square.}$$

In order to find n use the formula $n = s(s - 1)$ where s is the rows or columns in the matrix. For example, for a 10 x 10 matrix, $n = 10 \times 9 = 90$ degrees of freedom.

For two 10 x 10 matrices, this formula becomes:

$$Z = \frac{\sqrt{2X^2}}{\sqrt{2n - 1}} = 13.379$$

When Z is 2.58 or larger, the null hypothesis is rejected at the 0.01 level of confidence.

Darwin's chi-square for the indirect versus the direct teachers' matrices:

Matrix A = indirect teachers

Matrix B = direct teachers

Matrix A + Matrix B = Matrix C = Combined Matrix

$$X = 2(K - L - M + N) = 2(199.806 - 521.869 - 321.065 + 651.194)$$

$$X = 16.1338$$

$$Z = \frac{\sqrt{2X^2}}{\sqrt{2n - 1}} = 13.379 = \frac{\sqrt{2(16.1338)^2}}{\sqrt{2(90) - 1}}$$

$$Z = 9.432$$

The value of Z is 9.432 which is greater than 2.58. Therefore, the null hypothesis is rejected at the 0.01 level of confidence. In other words, the summary matrix for the indirect teacher is significantly different (at the 0.01 level of confidence) from the summary matrix for the direct teachers.

A close look at Tables VI, VII, VIII (Chapter III) reveals that some of the matrix cells have zero tallies.

Problems in the Darwin Procedure

Westbury (1968), in his unpublished doctoral thesis, makes the following statements about the use of Darwin's procedure:

Zero cell entries present theoretical as well as practical problems. Darwin's likelihood ratio criterion is closely related to tests of independence in contingency tables where $-2 \log \lambda$ (where λ is the likelihood ratio) is approximately distributed as chi-square with $(r - 1)(s - 1)$ degrees of freedom. It is a requirement of such tests that each cell must have a reasonable number of entries. It seems that this requirement is satisfied insofar as the theoretical basis of the Darwin statistic is concerned if the rows and columns of the matrices consistently have significant entries. The test is not substantially weakened by the absence of entries in individual cells. The test built into the program by which cells with zero entries are ignored is profitable statistically in that the probability value of zero $\log_e$ tends more often to zero than it does to infinity [Appendix B-8].

APPENDIX G

AN APL360/67 PROGRAM FOR CALCULATING DARWIN'S CHI-SQUARE

AN APL360/67 PROGRAM FOR CALCULATING
DARWIN'S CHI-SQUARE

The writer has developed an APL360/67 program to calculate Darwin's chi-square.

To illustrate the program and the use of Darwin's chi-square, consider the summary matrices for two teachers, say teachers A and B.

Step One: Vector A represents the hundred cell quantities of the matrix for teacher A.

Step Two: Vector B represents the hundred cell quantities of the matrix for teacher B.

Step Three: Check to see that $\sum A = 100$, $p_A = 100$, $\sum B = 100$, $p_B = 100$.

Step Four: Add a small quantity to every vector term in A and B because later calculations require taking the natural logarithm of each vector term (it is impossible to take $\log_e 0$).

$$A \leftarrow A + 0.00000001$$

$$B \leftarrow B + 0.00000001$$

Step Five: Create a vector C which is a combination of A and B.

$$C \leftarrow A + B$$

Step Six: Form a 10 x 10 matrix with vector A, i.e.,

$$D \leftarrow (10,10) p_A$$

Step Seven: Form a 10 x 10 matrix with vector B, i.e.,

$$E \leftarrow (10,10) p_B$$

Step Eight: Form a 10 x 10 matrix with vector C, i.e.,

$$F \leftarrow (10,10) p_C$$

Step Nine: CHIDAR

- [1] $K \leftarrow (+/(A \times \times A) + (+/B \times \times B))$
- [2] $L \leftarrow (+/((+/D) \times \times +/D)) + (+/((+/E \times \times +/E))$
- [3] $M \leftarrow +/(C \times \times C)$
- [4] $N \leftarrow +/((+/F) \times \times +/F)$
- [5] $X \leftarrow ((K + N) - (L + M)) \times 2$
- [6] $Z \leftarrow ((2 \times X^2) \times 2) - (13.379)$
- [7] ∇

APPENDIX H

RAW MATRICES, INDIVIDUAL TEACHERS:

EXPRESSED AS PER CENT

TABLE XV
TOTAL MATRIX FOR TEACHER 101
(Classified as Indirect)

	1	2	3	4	5	6	7	8	9	10	
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	0.00	0.00	0.00	2.70	0.70	0.20	0.20	0.00	1.10	0.40	
3	0.00	0.00	2.60	2.10	0.50	0.40	0.10	0.00	0.70	0.20	
4	0.00	0.10	0.30	3.20	0.90	0.40	0.30	5.50	7.50	0.30	
5	0.00	0.10	0.20	3.00	13.90	1.40	0.20	0.00	1.60	0.40	
6	0.00	0.10	0.00	0.50	0.70	2.00	0.10	0.00	0.80	0.40	
7	0.00	0.00	0.10	0.90	0.80	0.30	0.50	0.00	0.20	0.60	
8	0.00	1.50	0.10	3.10	0.50	0.00	0.30	0.00	0.20	0.10	
9	0.00	3.40	3.10	2.40	1.80	0.40	0.60	0.00	12.50	0.20	
10	0.00	0.10	0.20	2.50	3.30	0.50	1.00	0.30	1.70	1.00	
Total	0.00	5.30	6.60	20.40	23.10	5.60	3.30	5.80	26.30	3.60	100.00

Total Number of Tallies = 1921

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{32.30}{32.00} = 1.009$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 64.30\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 32.10\%$$

$$\text{Per cent Silence} = \text{Column 10} = 3.60\%$$

TABLE XVI
TOTAL MATRIX FOR TEACHER 102
(Classified as Average)

	1	2	3	4	5	6	7	8	9	10	
1	0.20	0.00	0.00	0.10	0.30	0.10	0.00	0.10	0.00	0.00	
2	0.10	0.00	0.10	1.10	1.79	0.10	0.10	0.00	0.60	0.30	
3	0.00	0.00	1.20	1.20	0.80	0.00	0.20	0.00	0.60	0.10	
4	0.00	0.10	0.00	2.79	0.80	0.20	0.00	7.36	2.09	0.70	
5	0.10	0.20	0.50	4.58	17.50	1.69	0.60	0.00	3.28	2.09	
6	0.10	0.10	0.10	0.40	1.20	3.28	0.10	0.10	0.90	1.29	
7	0.00	0.00	0.10	0.50	0.40	0.30	0.10	0.20	0.50	0.40	
8	0.20	2.19	0.70	1.89	1.20	0.30	0.60	0.10	0.20	1.10	
9	0.00	1.59	1.29	0.90	4.08	0.80	0.40	0.00	3.08	2.79	
10	0.10	0.00	0.10	0.60	2.49	0.80	0.40	0.60	3.68	4.08	
Total	0.80	4.18	4.09	14.06	30.56	7.57	2.50	8.46	14.93	12.85	100.00

Total Number of Tallies = 2109

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{23.13}{40.63} = 0.569$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 63.76\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 23.39\%$$

$$\text{Per cent Silence} = \text{Column 10} = 12.85\%$$

TABLE XVII
TOTAL MATRIX FOR TEACHER 103
(Classified as Average)

	1	2	3	4	5	6	7	8	9	10	
1	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	
2	0.00	0.00	0.15	2.00	2.74	0.22	0.15	0.30	0.52	0.30	
3	0.00	0.00	0.67	1.41	0.67	0.00	0.00	0.00	0.00	0.15	
4	0.00	0.00	0.07	2.08	1.63	0.52	0.30	14.39	3.48	1.26	
5	0.00	0.00	0.15	6.89	10.38	1.56	0.30	0.44	0.74	1.04	
6	0.15	0.00	0.00	0.59	0.74	1.70	0.52	0.59	0.22	1.78	
7	0.00	0.15	0.07	1.33	0.82	0.82	0.37	0.37	0.59	0.44	
8	0.00	5.33	0.82	5.63	1.85	0.37	1.78	0.15	0.22	0.52	
9	0.00	1.70	0.96	1.63	1.04	0.22	1.04	0.00	2.08	0.59	
10	0.00	0.00	0.00	1.19	2.08	1.04	0.15	0.44	1.41	1.85	
Total	0.15	7.18	2.89	22.75	21.95	6.60	4.61	16.68	9.26	7.93	100.00

Total Number of Tallies = 1792

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{32.97}{33.16} = 0.994$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 66.13\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 25.94\%$$

$$\text{Per cent Silence} = \text{Column 10} = 7.93\%$$

TABLE XVIII

TOTAL MATRIX FOR TEACHER 104
(Classified as Indirect)

	1	2	3	4	5	6	7	8	9	10	
1	0.10	0.05	0.00	0.16	0.00	0.05	0.05	0.05	0.10	0.05	
2	0.00	0.10	0.16	6.77	1.58	0.52	0.52	0.05	0.52	1.04	
3	0.00	0.00	0.52	1.25	0.21	0.10	0.16	0.00	0.05	0.26	
4	0.21	0.00	0.16	3.13	0.57	0.57	0.63	10.00	7.81	1.98	
5	0.00	0.05	0.05	3.18	5.06	0.83	0.10	0.00	0.10	0.73	
6	0.00	0.10	0.05	1.25	0.68	1.77	0.31	0.05	0.38	1.25	
7	0.05	0.10	0.16	2.24	0.42	0.21	0.83	0.26	0.38	0.47	
8	0.21	5.01	0.63	2.50	0.38	0.47	0.99	0.16	0.31	0.57	
9	0.00	5.53	0.73	2.34	0.21	0.21	0.78	0.00	6.20	0.63	
10	0.00	0.26	0.10	2.10	1.15	1.15	0.68	0.73	0.73	4.70	
Total	0.57	11.20	2.56	24.92	10.26	5.88	5.05	11.30	16.58	11.68	100.00

Total Number of Tallies =1986

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{39.25}{21.19} = 1.852$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 60.44\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 27.88\%$$

$$\text{Per cent Silence} = \text{Column 10} = 11.68\%$$

TABLE XIX
TOTAL MATRIX FOR TEACHER 105
(Classified as Direct)

	1	2	3	4	5	6	7	8	9	10	
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	0.00	0.00	0.00	1.10	1.18	0.07	0.29	0.00	0.66	0.59	
3	0.00	0.00	0.15	0.37	0.22	0.08	0.00	0.00	0.07	0.08	
4	0.00	0.00	0.15	1.25	0.95	0.22	0.37	5.81	2.13	1.03	
5	0.00	0.51	0.07	3.53	11.32	1.32	1.03	0.07	3.46	4.19	
6	0.00	0.00	0.00	0.44	0.66	1.55	0.37	0.15	0.59	2.43	
7	0.00	0.00	0.00	0.88	1.55	0.22	1.55	0.15	0.88	2.28	
8	0.00	2.28	0.00	0.95	1.55	0.22	0.74	1.10	0.22	0.37	
9	0.00	0.95	0.59	1.62	4.05	0.95	1.91	0.00	1.91	1.84	
10	0.00	0.15	0.00	1.77	3.90	1.55	1.25	0.14	3.97	10.05	
Total	0.00	3.89	0.96	11.91	25.38	6.18	7.51	7.42	13.89	22.86	100.00

Total Number of Tallies = 2201

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{16.76}{39.07} = 0.429$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 55.83\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 21.31\%$$

$$\text{Per cent Silence} = \text{Column 10} = 22.86\%$$

TABLE XX
TOTAL MATRIX FOR TEACHER 106
(Classified as Average)

	1	2	3	4	5	6	7	8	9	10	
1	0.07	0.00	0.00	0.14	0.07	0.00	0.00	0.00	0.00	0.00	
2	0.07	0.14	0.14	1.44	1.22	0.36	0.29	0.14	1.44	0.07	
3	0.00	0.00	0.79	1.51	0.57	0.14	0.00	0.00	0.36	0.22	
4	0.00	0.07	0.22	1.87	1.15	0.14	0.36	4.30	6.89	0.29	
5	0.07	0.29	0.00	3.58	13.19	2.58	0.50	0.00	6.17	1.36	
6	0.00	0.14	0.07	0.43	1.29	3.08	0.07	0.00	1.72	1.07	
7	0.00	0.07	0.14	0.93	0.57	0.14	0.29	0.00	1.07	0.36	
8	0.00	1.22	0.14	1.87	0.72	0.00	0.14	0.00	0.07	0.36	
9	0.00	3.37	2.01	2.73	7.95	0.79	1.58	0.00	3.37	2.87	
10	0.07	0.00	0.07	0.86	1.07	0.65	0.29	0.14	3.51	0.50	
Total	0.28	5.30	3.58	15.36	27.80	7.88	3.52	4.58	24.60	7.10	100.00

Total Number of Tallies = 1622

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{24.52}{39.20} = 0.626$$

Per cent Teacher Talk = Column 1-7 = 63.72%

Per cent Pupil Talk = Column 8-9 = 29.18%

Per cent Silence = Column 10 = 7.10%

TABLE XXI
TOTAL MATRIX FOR TEACHER 107
(Classified as Indirect)

	1	2	3	4	5	6	7	8	9	10	
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	
2	0.00	0.00	0.13	2.08	1.56	0.00	0.13	0.52	1.04	0.26	
3	0.00	0.00	1.04	1.30	0.78	0.00	0.00	2.21	0.52	0.13	
4	0.00	0.00	0.00	1.43	0.78	0.13	0.13	10.01	5.86	0.52	
5	0.00	0.00	0.13	6.12	6.25	0.52	0.00	0.39	2.60	0.65	
6	0.00	0.00	0.13	0.65	0.26	0.78	0.78	0.78	0.78	0.52	
7	0.00	0.13	0.00	0.78	0.91	1.04	0.26	0.26	0.39	0.26	
8	0.13	3.25	0.91	5.34	2.08	1.30	1.04	6.23	0.00	0.65	
9	0.00	2.34	1.43	2.08	3.25	0.26	1.30	0.00	4.29	2.21	
10	0.00	0.00	0.00	1.04	0.91	0.65	0.39	0.52	1.82	0.52	
Total	0.13	5.72	3.77	20.82	16.78	4.68	4.03	20.92	17.30	5.85	100.00

Total Number of Tallies = 2026

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = I/D = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{30.44}{25.49} = 1.194$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 55.93\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 38.22\%$$

$$\text{Per cent Silence} = \text{Column 10} = 5.85\%$$

TABLE XXII
TOTAL MATRIX FOR TEACHER 108
(Classified as Direct)

	1	2	3	4	5	6	7	8	9	10	
1	0.31	0.00	0.00	0.31	1.10	0.31	0.00	0.00	0.08	0.00	
2	0.00	0.00	0.07	1.73	1.34	0.31	0.16	0.24	0.00	0.16	
3	0.00	0.00	0.71	0.71	0.47	0.00	0.16	0.00	0.08	0.16	
4	0.16	0.00	0.00	2.20	1.81	0.39	0.16	6.06	3.15	1.42	
5	0.79	0.16	0.08	4.41	33.65	2.05	0.31	0.08	0.79	1.57	
6	0.16	0.00	0.00	0.71	1.73	2.28	0.24	0.39	0.00	0.79	
7	0.07	0.24	0.00	1.10	0.79	0.08	0.47	0.24	0.16	0.08	
8	0.16	2.99	0.55	1.10	0.63	0.31	0.94	0.31	0.00	0.79	
9	0.24	0.71	0.71	1.65	0.55	0.31	0.47	0.00	0.71	0.55	
10	0.24	0.00	0.16	1.34	1.97	0.31	0.16	0.39	0.87	3.70	
Total	2.13	4.10	2.28	15.26	44.04	6.35	3.07	7.71	5.84	9.22	100.00

Total Number of Tallies = 2194

$$\frac{\text{Indirect Influence}}{\text{Direct Influence}} = \text{I/D} = \frac{\text{Column 1-4}}{\text{Column 5-7}} = \frac{23.77}{53.46} = 0.445$$

$$\text{Per cent Teacher Talk} = \text{Column 1-7} = 77.23\%$$

$$\text{Per cent Pupil Talk} = \text{Column 8-9} = 13.55\%$$

$$\text{Per cent Silence} = \text{Column 10} = 9.22\%$$

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